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Space Station Freedom User's Guide



(NASA-TM-108105) SPACE STATION
FREEDOM USER'S GUIDE (NASA) 89-0

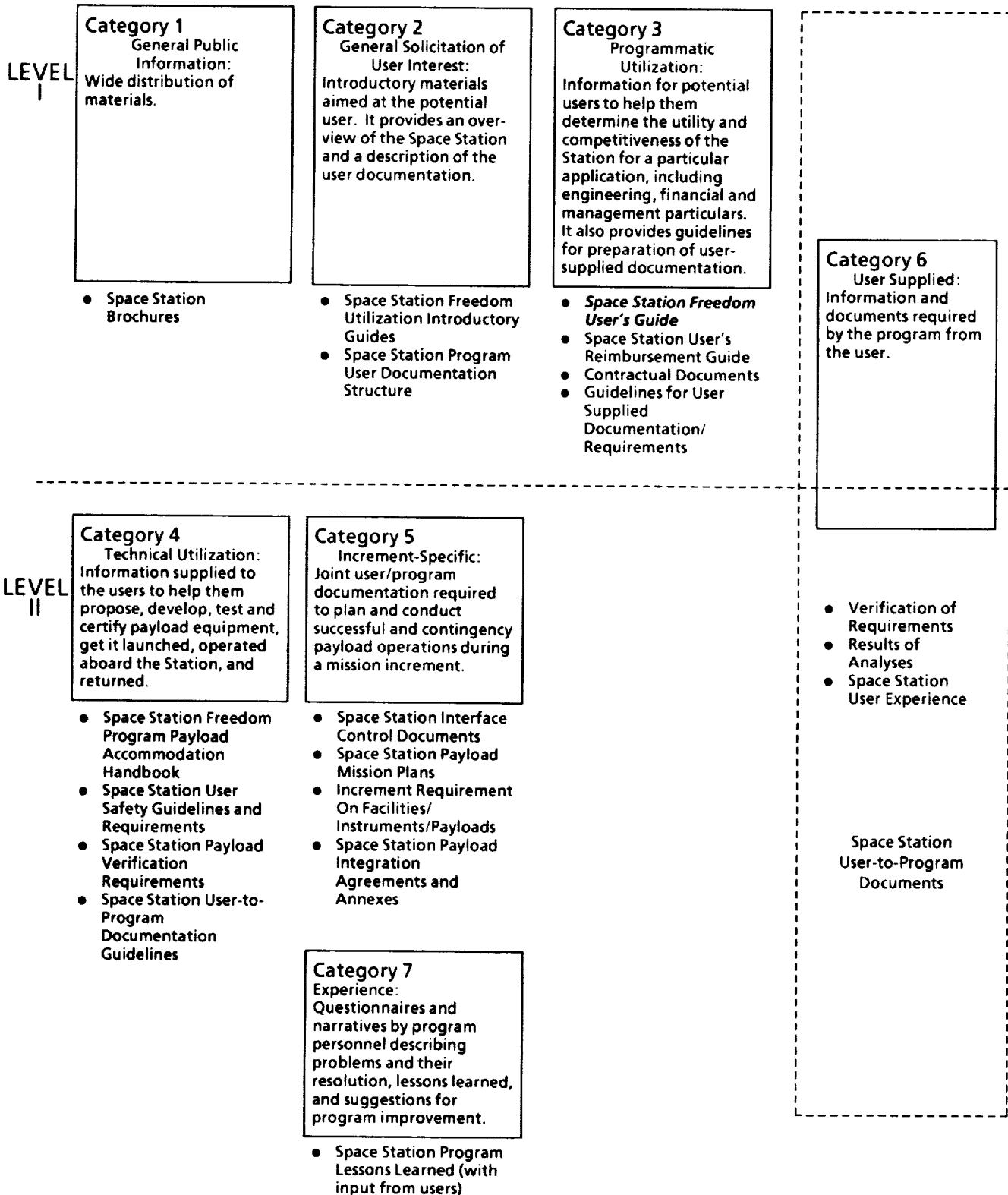
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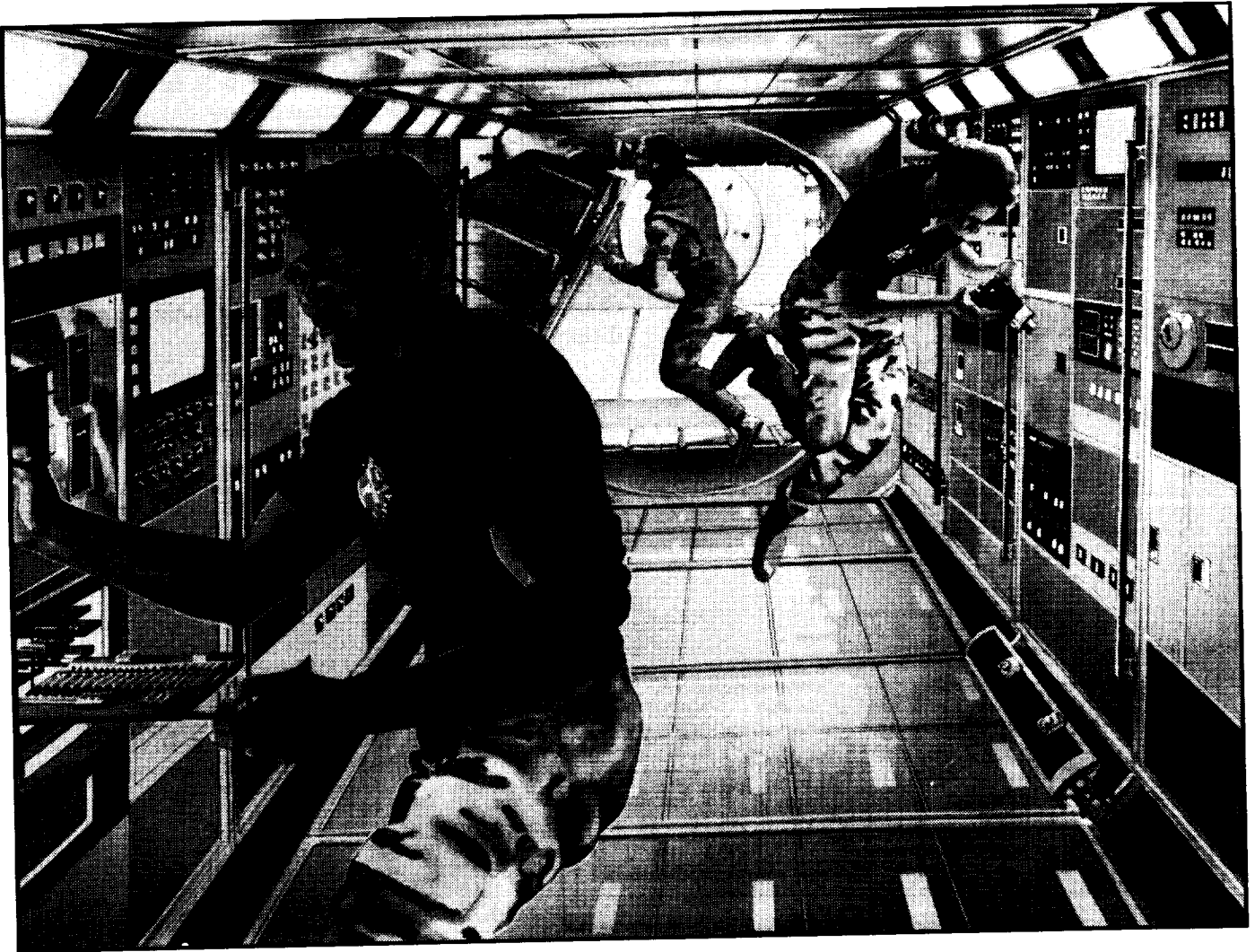
Space Station Freedom Program User Documentation Structure



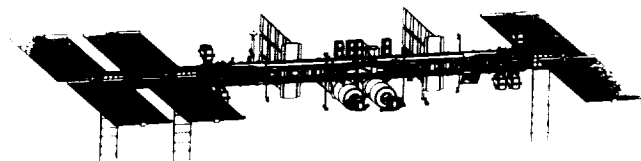


Space Station Freedom

User's Guide



August 1992

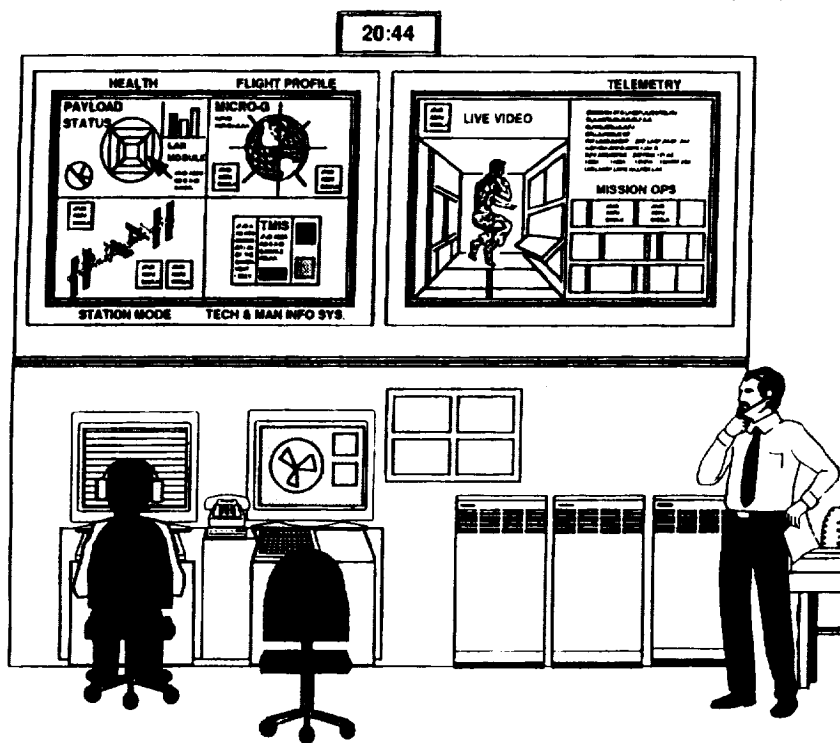
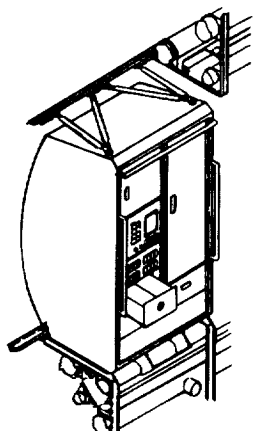


Dear Prospective User:

This *Space Station Freedom User's Guide* has been prepared with you in mind. It is designed to answer some of the preliminary questions you may have about the Space Station Freedom program and to give you information about the resources Space Station Freedom will provide to its users.

Please let me know if you have any comments or suggestions for improving this guide. It is updated periodically to reflect the latest program changes. If you wish to receive these updates or additional information, contact:

Office of Space Flight
 Spacelab/Space Station Utilization Program
 User Integration Division
 Code MG
 National Aeronautics and Space
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1. INTRODUCTION

Purpose

This guide is intended to inform prospective users of the accommodations and resources provided by the Space Station Freedom program. Using this information, they can determine if Space Station Freedom is an appropriate laboratory or facility for their research objectives. The steps that users must follow to fly a payload on Freedom are described.

Scope

This guide covers the accommodations and resources available on the Space Station during the Man-Tended Capability (MTC) period, scheduled to begin the end of 1996, and at Permanently Manned Capability (PMC) beginning in late 1999. This guide is written for prospective users of NASA controlled accommodations and resources.

This guide will be distributed to a wide audience of potential users who may be interested in seeking

NASA sponsorship of their Space Station Freedom research. These users may come from the academic and industrial communities, from within NASA or other government agencies.

Additional program documents, such as the Space Station Freedom Program (SSFP) Payload Accommodation Handbook, provide more detailed information to enable users to design, build and operate their payloads. The program user documentation structure can be found inside the front cover of this guide. In addition, a listing of additional relevant documents can be found in Appendix B.

Status

The *Space Station Freedom User's Guide* reflects currently planned Station capabilities for research, prior to completion of critical design reviews. This guide will be updated to reflect future program changes.

Background

In May 1982, NASA formed a Space Station Task Force to develop concepts for a permanently inhabited Space Station to be deployed in low Earth orbit (LEO). In January 1984, President Reagan committed the nation to "developing a permanently manned Space Station and to do it within a decade." Canada, the European Space Agency (ESA) and Japan agreed to become partners. On July 18, 1988, President Reagan named the Space Station "Freedom."

The program objectives for Space Station Freedom are:

- Establish a permanently manned, multipurpose facility in low Earth orbit in the 1990s;
- Enhance and evolve mankind's ability to live and work safely in space;
- Stimulate technologies of national importance by using them to provide Space Station Freedom capabilities;
- Provide long-term, cost-effective operation and utilization of continually improving facilities for scientific, technological, commercial and operational activities enabled or enhanced by the presence of man in space;
- Promote substantial international cooperation in space;
- Create and expand opportunities for private-sector activity in space;
- Provide for the evolution of Space Station Freedom to meet future needs and challenges; and
- Foster public knowledge and understanding of the role of habitable space system capabilities in the evolution of human experience outside Earth's atmosphere.

Space Station Development

The Space Station comprises a manned base and the associated ground support. NASA provides the crew Habitation Module, a Laboratory Module, the truss structure and all distributed systems and sub-

systems. ESA provides the Attached Pressurized Module (APM), including an unpressurized exposed pallet. Japan provides the Japanese Experiment Module (JEM), which includes a pressurized module, an unpressurized exposed facility (EF) and an experiment logistics module (ELM). Canada provides the Mobile Servicing System (MSS), the MSS maintenance depot and the Special Purpose Dexterous Manipulator (SPDM). NASA also provides a Mobile Transporter (MT) which enables the MSS to move along the truss. Each partner provides the appropriate Space Station-unique ground elements.

Space Station Freedom development is managed by NASA's Office of Space Systems Development (OSSD). Overall program management resides at NASA headquarters in Washington, D.C. NASA Headquarters is responsible for top-level program management and strategic planning. The program's day-to-day management is conducted at the SSF Program Office (SSFPO), located in Reston, Virginia. The SSFPO is responsible for systems engineering and analysis, program planning and resource control for both development and operations, configuration management, and integration of elements and payloads into an operational system. There are three NASA "work package" centers responsible for actual hardware development and fabrication.

The Marshall Space Flight Center (MSFC) in Huntsville, Alabama, is responsible for the U.S. laboratory and habitation modules, pressurized shells for resource nodes, and environmental control system. The Johnson Space Center (JSC) in Houston, Texas is responsible for the pre-integrated truss structure, integrated resource nodes, mobile transporter, crew training and several distributed systems including the external thermal control system and data management system. The Lewis Research Center (LeRC) in Cleveland, Ohio is responsible for Freedom's power generation, management and distribution system.

The Space Station Mission Operations Project Office, located in Houston, Texas, is responsible for all JSC activities associated with Freedom mission operations. Ground operations support for Shuttle launch and return is conducted from the Space Station Project Office at the Kennedy Space Center (KSC), Florida. Payload operations and payload analytical integration are performed by the Space Station Freedom Operations and Utilization Office within the Payload Projects Office at MSFC.

A phased approach will be used to assemble Space Station Freedom. The first Shuttle assembly flight, or First Element Launch (FEL), is scheduled for late 1995. FEL includes a truss segment and those subsystems necessary to sustain the initial elements in orbit. The addition of the U.S. Laboratory Module, scheduled for late 1996, will mark the beginning of Freedom's Man-Tended Capability (MTC). The Shuttle will regularly visit Freedom for housekeeping, payload operations and maintenance. During the MTC period, eight utilization flights, dedicated to research activities on the Space Station, are planned. Permanently Manned Capability (PMC), scheduled for late 1999, will follow the addition of the Habitation Module, the Assured Crew Return Vehicle (ACRV) and occupation of Freedom by a permanent crew.

Operations Responsibilities

NASA, with the support of the international partners, is responsible for planning and directing the day-to-day operation of the manned base.

Definitions

During their participation in the SSFP, users will become familiar with program terminology. As an introduction, some of the basic terms are defined below.

Space Station Freedom

The spacecraft and all of the NASA and international partner space and ground components

associated with development, operations and utilization.

User or Researcher

An individual or organization making use of NASA's resources and accommodations on Space Station Freedom to conduct scientific research, technology development or commercial activities.

Sponsor

An organization which represents users to the SSFP.

Payload

A specific complement of equipment, specimens, software and operations to perform research in space.

Payload Accommodations Manager (PAM)

A user's point of contact with the SSFP. The PAM is designated after the user has received a commitment from the program to accommodate the payload. The PAM assists the user in completing all assessments and documentation needed for the payload.

Increment

The period of time between two consecutive Space Shuttle dockings with Space Station Freedom.

Getting a Sponsor

Access to the microgravity environment of space is one of the most important features of Space Station Freedom. Currently, U.S. researchers using the Shuttle are only able to conduct experiments in space for a few days at a time. Freedom, expected to be in orbit for 30 years, will provide a laboratory in the microgravity environment for conducted over a period of months or years. This continuous, stable laboratory in orbit will be occupied by a permanent human crew, who will perform the experiments with guidance from researchers and ground crew.

Freedom provides the capability to conduct a wide range of scientific and technological investigations and commercial endeavors in areas such as:

| | |
|----------------------|-------------------------|
| Life Sciences | Communications |
| Materials Science | Space Structures |
| Combustion Processes | Automation and Robotics |

| | |
|------------------------|---------------------|
| Fluid Dynamics and | Information Systems |
| Transport Phenomena | Human Systems |
| Observational Research | Engineering |

In order to make use of the accommodations and resources that have been allocated to NASA, one must obtain a sponsor. The NASA offices and the user communities they sponsor are shown in Figure 1-1. Commercial cooperative users may obtain sponsorship through a negotiated agreement with the Office of Commercial Programs (OCP). Commercial reimbursable users may obtain sponsorship by submitting a Request for Flight (RFF) to the Office of Space Flight (OSF). Other users may obtain sponsorship by submitting a proposal to the Office of Space Science and Applications (OSSA) or the Office of Aeronautics and Space Technology (OAST).

All proposals undergo a series of reviews to determine their compatibility with the sponsor's goals; with the goals, capabilities and constraints of the

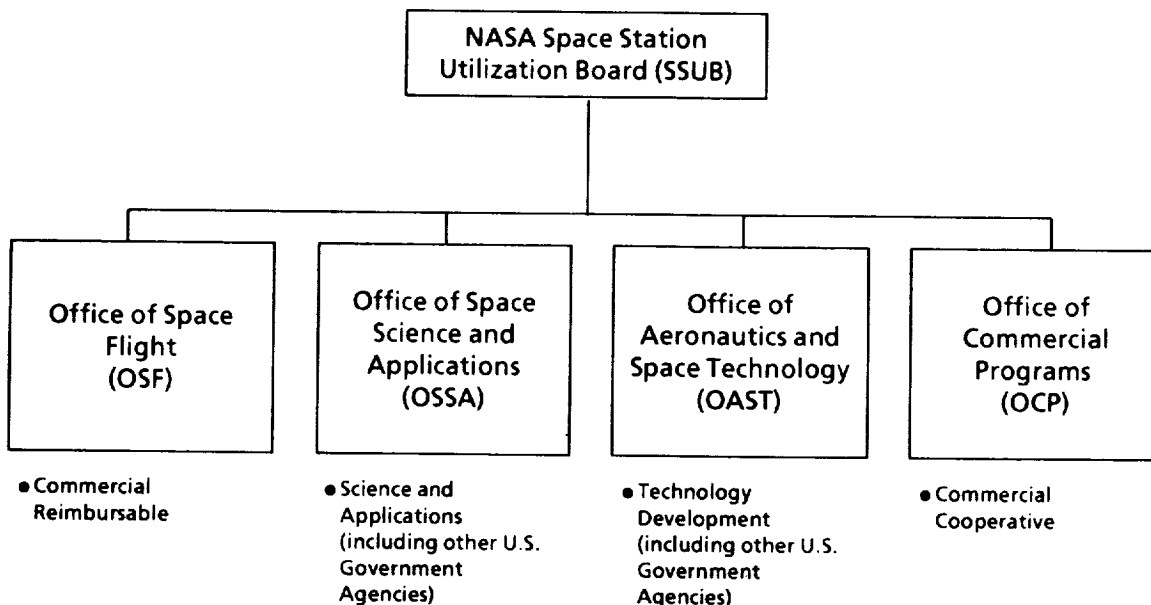


Figure 1-1 Sponsors of NASA Resources

Space Station Freedom program; and with the resource allocations specified by NASA.

Each NASA sponsor represents its respective users on the Space Station Utilization Board (SSUB). The SSUB divides the NASA allocated accommodations and resources among the sponsors for their user communities. Each NASA sponsor presents its candidate user payloads to the SSUB. The SSUB ensures that the NASA sponsor utilization plans do not exceed the resources allocated to that user community or sponsor.

Science

NASA science researchers are sponsored by the Office of Space Science and Applications (OSSA). OSSA periodically issues Announcements of Opportunity (AOs), which solicit proposals for a specific area of research. AOs are announced through NASA mailing lists and in the *Commerce Business Daily*. AOs solicit proposals for research involving major hardware procurements. The appropriate scientific discipline for proposals and OSSA's broad program objectives are specified in the AO, which also delineates the proposal format, deadlines, where to send proposals, the selection schedule and evaluation criteria.

OSSA periodically issues NASA Research Announcements (NRAs) which are used to solicit proposals to conduct research using existing hardware or involving minor hardware development. NRAs solicit proposals from a wide variety of individuals, and typically include a description of the program proposal guidelines, deadlines, where to send proposals and evaluation criteria.

OSSA has agreements with a number of U.S. government agencies to integrate and coordinate their Space Station science utilization activities. These agencies select investigations in accordance with their program objectives, but their Space Station utilization is integrated by OSSA into the science element of NASA Space Station Freedom utilization plans.

Technology Development Users

The Office of Aeronautics and Space Technology (OAST) serves as the representative for NASA and

other U.S. government agencies for the on-orbit evaluation of advanced space technologies utilizing Space Station Freedom.

OAST solicits proposals by periodically issuing AOs to industry, universities and NASA Centers. Proposals are selected by a rigorous peer and management review process. The ongoing flight experiments program emphasizes small and inexpensive experiments utilizing the Space Shuttle or expendable launch vehicles as appropriate. The same policy applies to the utilization of Space Station Freedom for technology development and validation.

OAST provides development and integration funding for selected advanced technology experiments that provide fundamental, low-gravity derived information, space environmental effects or essential system components for future NASA missions.

Commercial Cooperative Users

The Centers for the Commercial Development of Space (CCDSs) are the primary points of entry into the program for commercial cooperative researchers, or those who are partially funded by NASA. These centers are nonprofit consortia of industry, academia and government created to conduct space-based, high-technology research and development activities.

The Office of Commercial Programs (OCP) also negotiates a number of joint agreements with industry to encourage the commercial use of space. Through these agreements, NASA provides assistance, services and facilities to help reduce the risks associated with commercial space ventures. Each agreement offers different opportunities generally in return for some type of compensation or *quid pro quo* arrangement which is determined during agreement negotiations. These agreements include:

- Joint Endeavor Agreements which involve no exchange of funds. Private industry funds payloads and NASA provides accommodations and resources.
- Space Systems Development Agreements which provide industry with a deferred payment schedule for accommodations and resources. This allows the user to defer payments until revenues from the payload begin to accrue.

- Technical Exchange Agreements in which NASA and a company agree to exchange technical information and cooperate in a ground-based research program.
- Other agreements, such as Memoranda of Understanding and Memoranda of Agreement, which provide a framework for meeting specific commercial interests.

OCP reviews a proposed payload and may then choose to negotiate and sign the appropriate agreement.

Commercial Reimbursable Users

Users whose commercial activities are completely self-funded are known as commercial reimbursable users. They should contact the Office of Space Flight to discuss their plans. After submittal of an RFF and required earnest money, OSF reserves the needed resources and begins evaluation of the request. A compatibility analysis is performed and, if the payload is compatible, negotiations are begun. The negotiations result in a Space Station utilization services agreement between OSF and the user. This is in the form of a legal contract consisting of the terms and conditions for the provision of services. It includes the identification and quantification of services to be provided, schedules, price and financial arrangements, insurance provisions, involvement of a user provided payload scientist on board, liability provisions, and other information.

Points of Contact

Questions concerning general information about Space Station Freedom utilization should be addressed to:

Office of Space Flight
 Spacelab/Space Station Utilization Program
 User Integration Division
 Code MG
 NASA Headquarters
 Washington, DC 20546

For specific information concerning commercial reimbursable payload opportunities contact:

Office of Space Flight
 NASA Headquarters
 Code MB
 Washington, DC 20546

For specific information regarding Space Station payloads and/or the specific requirements of a sponsor, contact the appropriate NASA sponsor:

Science and applications opportunities:

Dr. Roger Crouch
 Microgravity Science and
 Applications Division
 Office of Space Science & Applications
 NASA Headquarters
 Code SN
 Washington, DC 20546

Dr. J. Richard Keefe
 Life Sciences Division
 Office of Space Science & Applications
 NASA Headquarters
 Code SB
 Washington, DC 20546

Technology development opportunities:

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 Space Experiments Office
 Office of Aeronautics and
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 Washington, DC 20546

Commercial cooperative opportunities:

James Fountain
 Office of Commercial Programs
 PS 05
 George C. Marshall Space Flight Center
 Huntsville, AL 35812

2. SPACE STATION FREEDOM DESCRIPTION

General

Space Station Freedom will orbit from 180 n.m. (333 km) to 240 n.m. (444 km) above the Earth at a 28.5° inclination. It will orbit Earth approximately every 90 minutes.

Space Station Freedom will be assembled over a four-year period beginning in the fall of 1995. The Space Shuttle will make 18 Mission Build (MB) flights during this period to transport the components of the

Space Station into orbit. The first flight, known as the First Element Launch (FEL), is scheduled for the fall of 1995. Man-Tended Capability (MTC) (Figure 2-1) begins with the arrival of the U.S. Laboratory Module, in late 1996, on the sixth Space Shuttle flight. The overall flight sequence for Space Station Freedom is presented in Figure 2-2.

During MTC, eight Utilization Flights (UF) are planned strictly for research activities on Freedom. The first of these flights is scheduled for the spring of 1997. The Shuttle will be docked at the Space Station

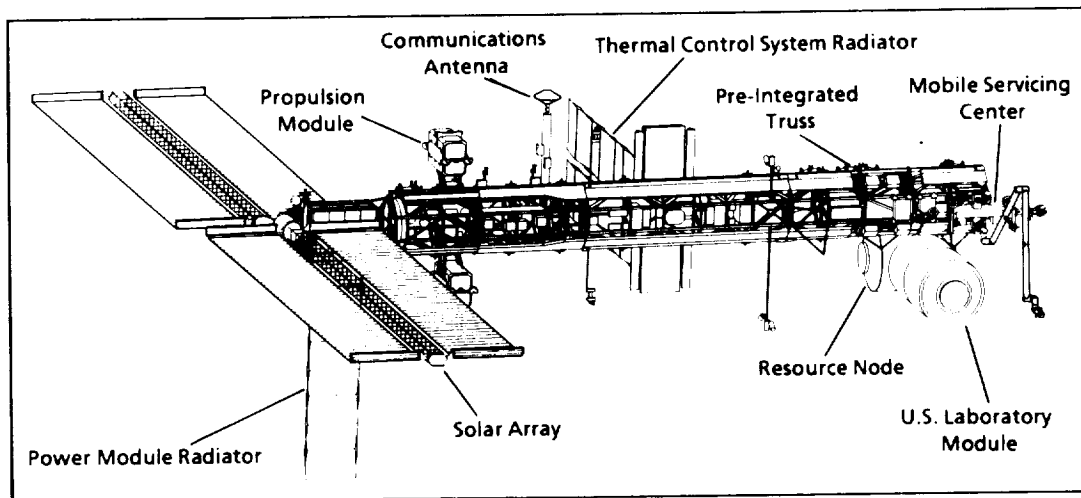
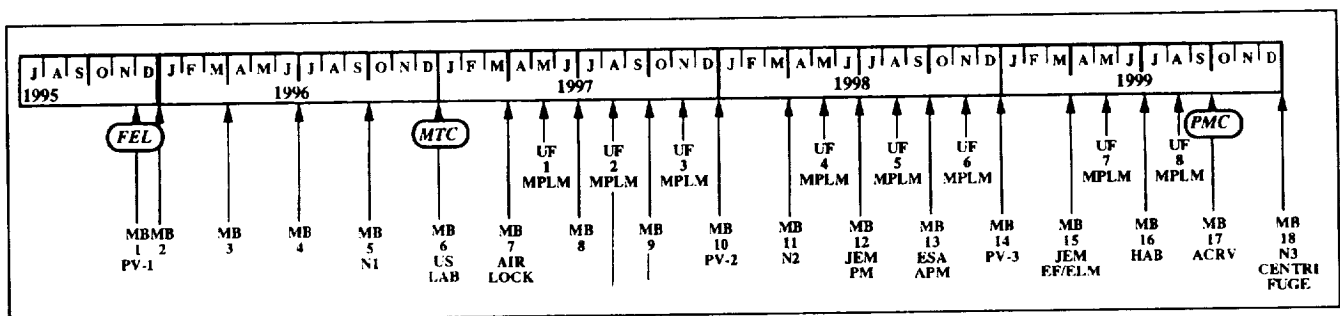


Figure 2-1 Space Station Freedom Man-Tended Capability (MTC)



Legend:

ACRV - Assured Crew Return Vehicle
APM - Attached Pressurized Module
EF - Exposed Facility
ELM - Experiment Logistics Module
FEL - First Element Launch

HAB - Habitation Module
MB - Mission Build Flight
MPLM - Mini Pressurized Logistics Module
MTC - Man-Tended Capability
N - Node

PMC - Permanently Manned Capability
PV - Photovoltaic Power Module including Solar Array
UF - Utilization Flight

Figure 2-2 Space Station Freedom Overall Flight Sequence

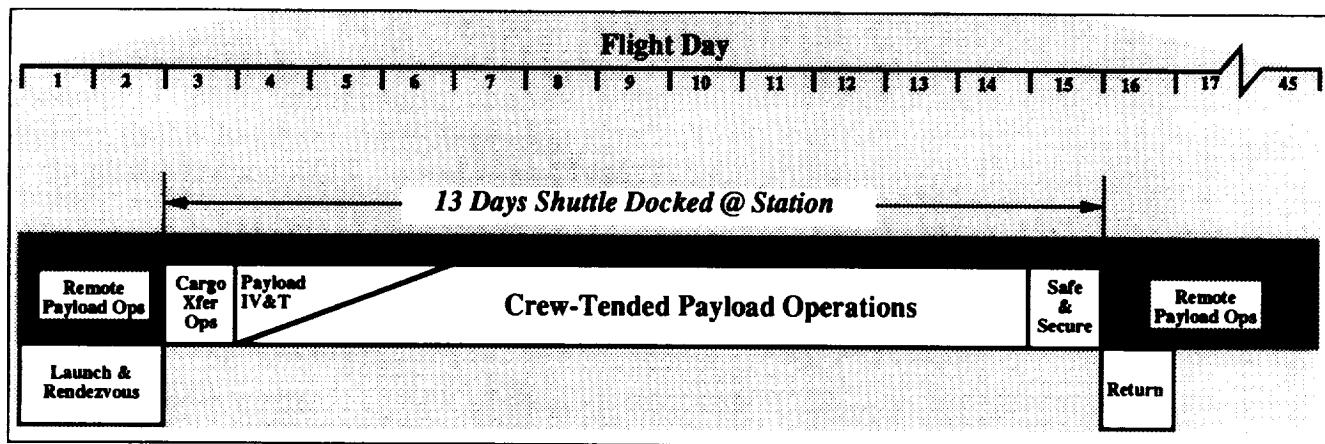


Figure 2-3 A Typical Space Station Freedom Utilization Flight Increment

for 13 days during these flights (Figure 2-3). Four crew members will be assigned to payload operations during these flights. They will operate payloads that require human presence; activate payloads that can operate independently until the next Utilization Flight; and return samples that have been produced or payloads that have operated unattended since the previous Utilization Flight.

Payloads will be accommodated in racks within Freedom's pressurized laboratory modules or externally as attached payloads (Figure 2-4).

At MTC, 11 kW of power will be available to 15 payload rack positions with a data downlink rate of 43 Mbps. The second photovoltaic power module will be attached in late 1997, increasing the available payload power to 19 kW. The JEM and ESA laboratories and the third photovoltaic power module will be installed on Freedom in 1998. The JEM Exposed Facility and the Experiment Logistics Module, the Habitation Module and the Assured Crew Return Vehicle (ACRV) will be added during 1999.

The addition of the ACRV will mark the beginning of permanently manned capability (PMC) (Figure 2-5). Thereafter, Freedom will have a crew of four permanently on board. The Shuttle flight following PMC will bring the Centrifuge Facility to the Space Station in late 1999. Freedom is designed to have a lifetime of not less than 30 years. A summary of its characteristics is presented in Table 2-1.

Space Station Freedom's accommodations and resources are allocated to each of the four international partners, including NASA, based upon international agreements.

Table 2-1 Summary of Space Station Freedom Characteristics¹

| Physical Parameters | MTC | PMC |
|---|-----------|-----------------|
| Length (ft/m) | 158/48 | 353/108 |
| Height ² (ft/m) | 243/74 | 243/74 |
| Weight (tons/metric tons) | 91/83 | 239/217 |
| Power, Orbital Average (kW) | | |
| (Total/Users) | 18.75/11 | 56.25/30 |
| Communication Rate Maximum (Mbps) | 43 | 43 |
| Pressurized volume (ft ³ /m ³) | 6,000/170 | 23,000/651 |
| Pressurized Environment (psia/kPa) | 10.2/71.4 | 14.7/104.4 |
| Orbital Parameters | | |
| Altitude (n.m./km) | | 180-240/333-444 |
| Inclination | | 28.5° |
| Velocity (mph/kmph) | | 18,000/29,000 |
| Attitude - Maximum Variation (deg/axis/orbit) | | 2.5 |

¹ All characteristics are approximate and subject to change.

² This is the height of the solar array

A quantitative summary of some of the accommodations and resources available to researchers during Freedom's assembly is presented in Figure 2-6.

Power for payloads reaches 30 kW, then decreases with the addition of the JEM and ESA APM, and returns to 30 kW with the addition of the third photovoltaic power module. The addition of the JEM and ESA APM also decreases the data downlink available to NASA, but increases the quantity of available payload racks. Following PMC, the number of crew members dedicated to research activities decreases from four to two, but they are on board permanently.

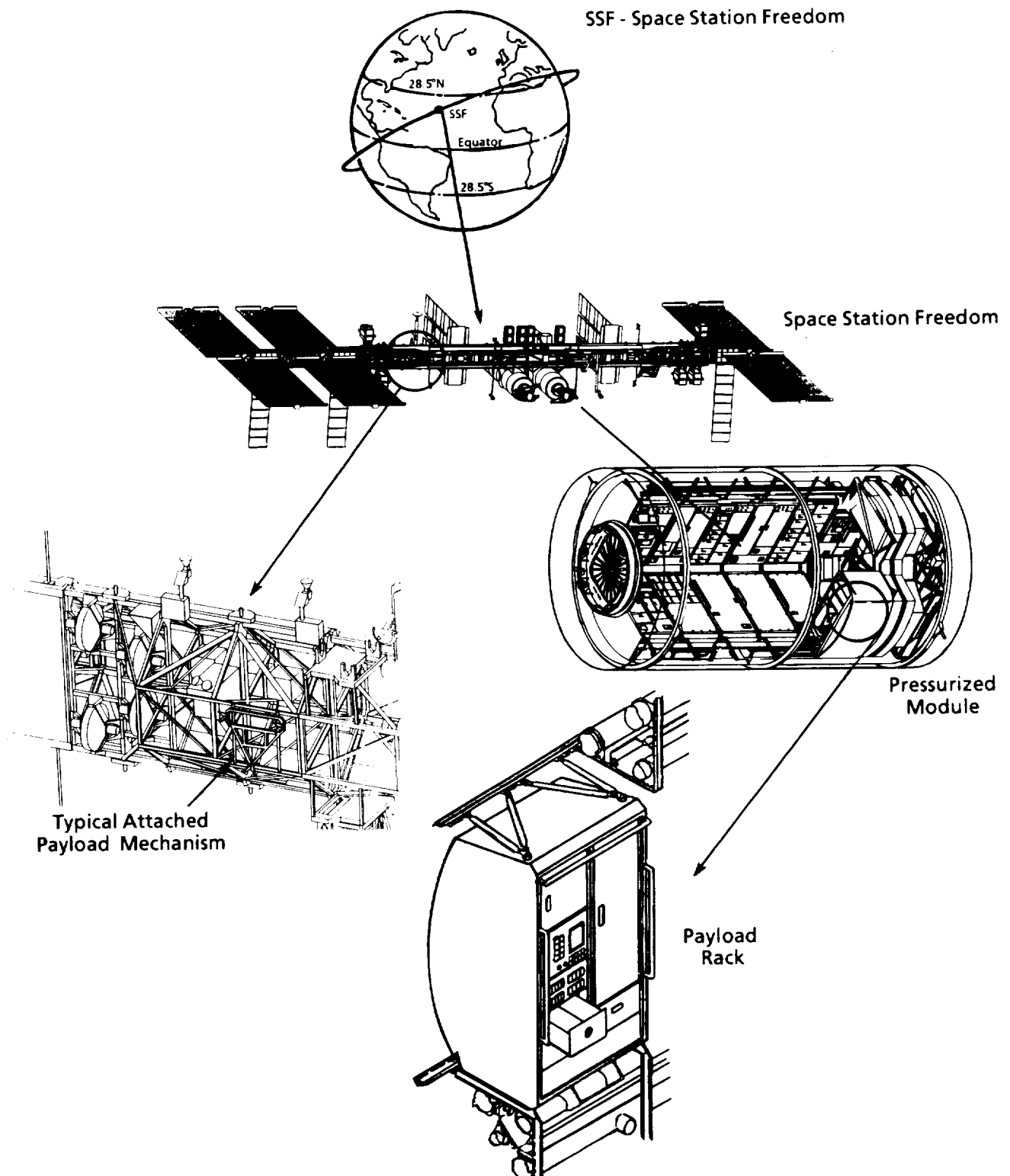


Figure 2-4 Examples of Space Station Freedom Payload Accommodations

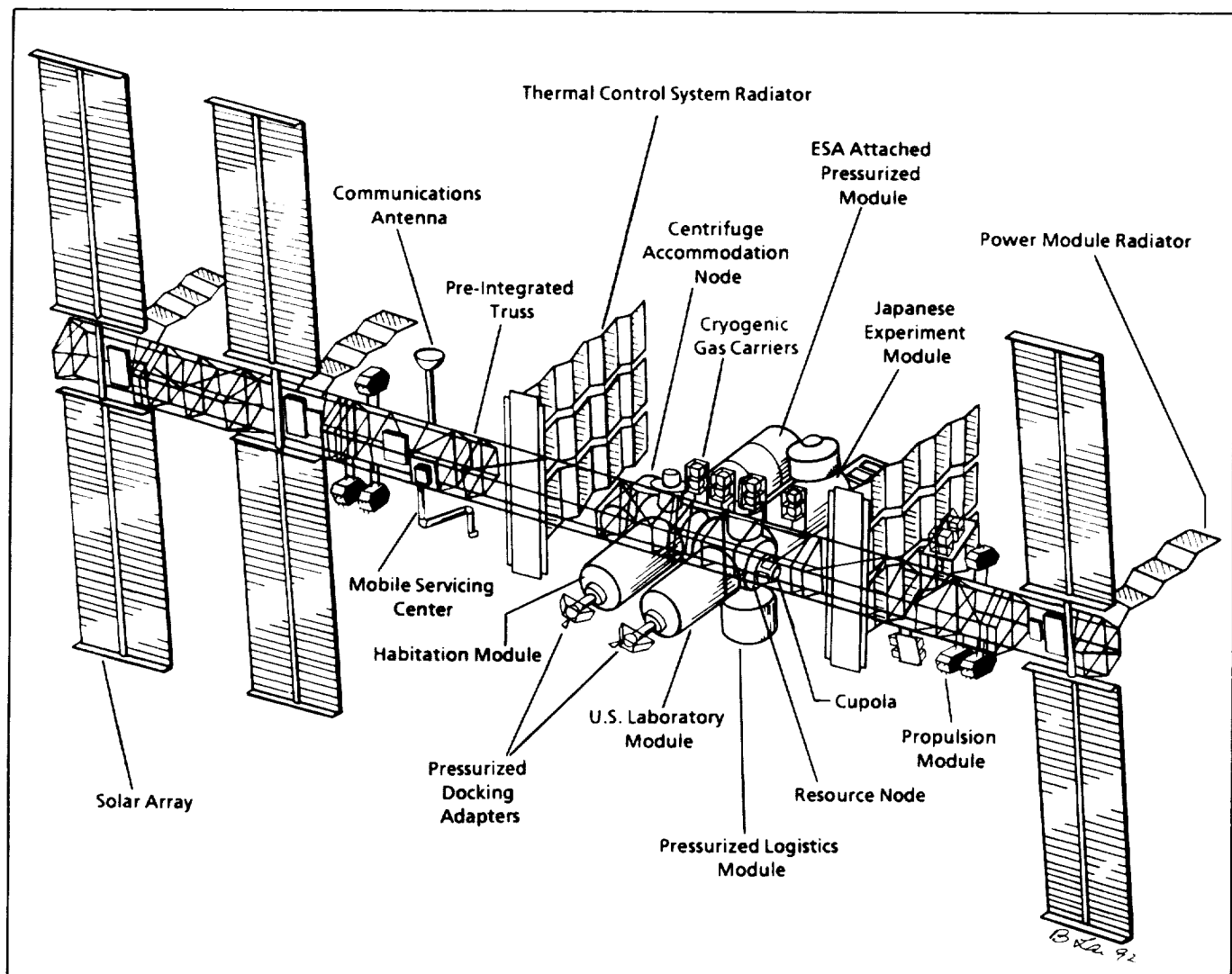


Figure 2-5 Permanently Manned Capability (PMC)

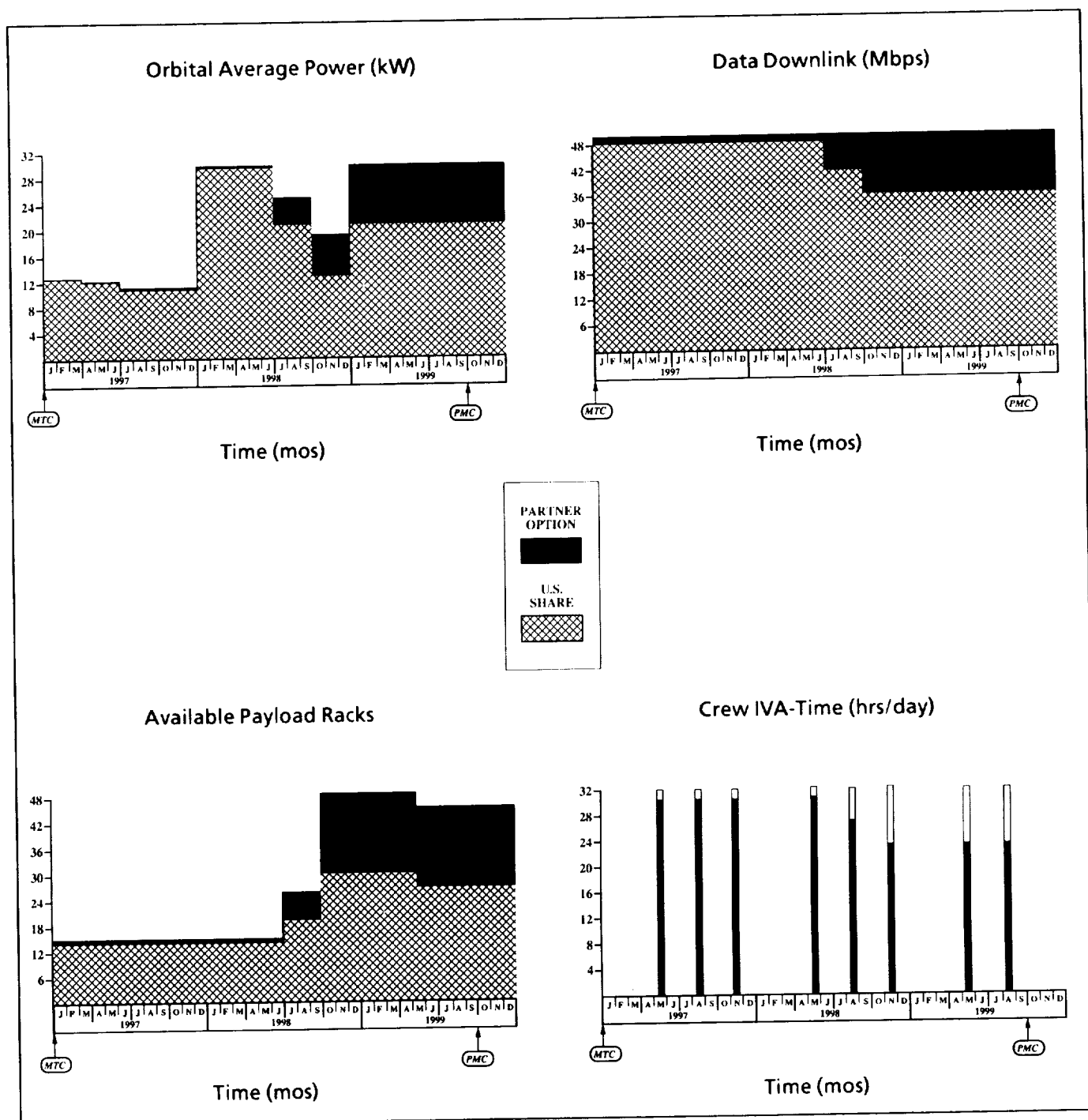


Figure 2-6 Payload Resource Allocations

Manned Base

The manned base is comprised of both pressurized and unpressurized elements including various modules, facilities and distributed systems.

Pressurized Elements

The pressurized elements of the manned base (Figure 2-7) that support researchers consist of:

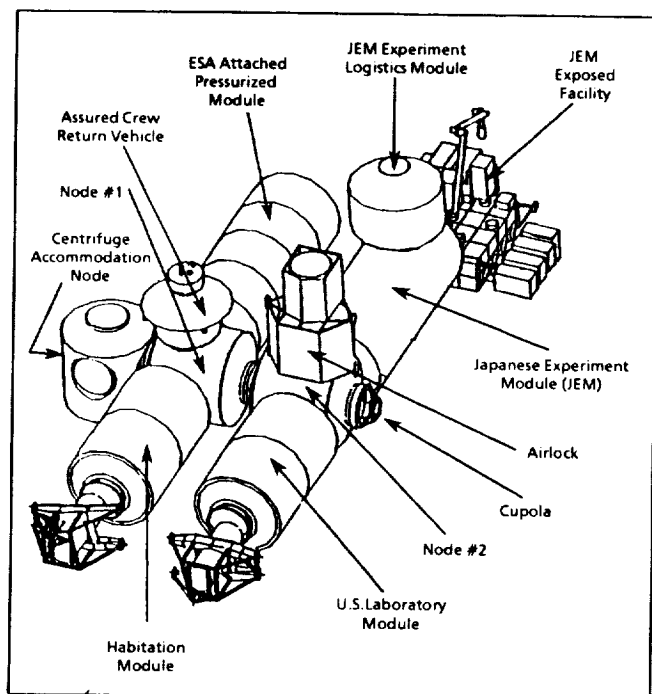


Figure 2-7 Pressurized Elements (PMC)

- The U.S. Laboratory Module
- The Habitation Module
- The Japanese Experiment Module (including the Experiment Logistics Module)
- The ESA Attached Pressurized Module
- Resource Nodes #1 and #2
- The Centrifuge Accommodation Node
- The Cupola
- The Pressurized Logistics Module

U.S. Laboratory Module (U.S. Lab)

The U.S. Laboratory Module (Figure 2-8) is a cylinder about 27 ft (8.2 m) long with a diameter of 14.4 ft (4.4 m). It provides a shirt-sleeve environment for astronauts, and is equipped with power supply, thermal control, environmental control and life support, and data handling systems.

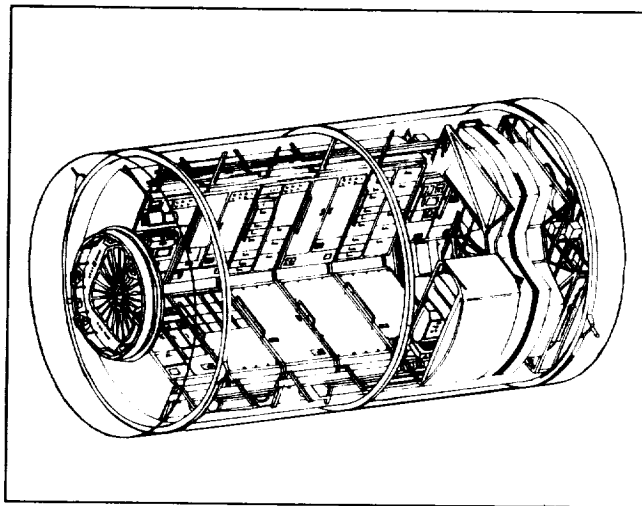


Figure 2-8 U.S. Laboratory Module

The entire module houses these systems and user payloads. Equipment and experiment racks are installed inside the module's floor, ceiling and port and starboard walls.

The laboratory is designed to accommodate many disciplines: research in basic biology, physics and chemistry; materials research and development requiring exposure to microgravity; life sciences research relating to long duration exposure to microgravity; and technology research and development, including automation and robotics. The U.S. Lab is also used to control attached payloads and to maintain and service Space Station systems and researcher facilities and equipment.

Habitation Module (Hab)

The Habitation Module (Figure 2-9) provides the living environment for up to four crew members. The Hab contains the galley, wardroom, personal hygiene facility and other provisions to maintain the health and well-being of the crew.

The Hab is an environmentally protected enclosure intended for long duration crew activity such as eating, sleeping and some work activities. The Hab is located parallel and adjacent to the U.S. Lab in the cluster of pressurized modules that make up the manned base and is the same size as the U.S. Lab.

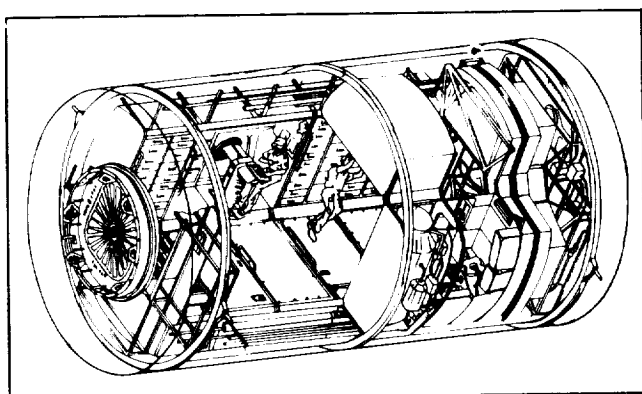


Figure 2-9 Habitation Module

Japanese Experiment Module (JEM)

The JEM pressurized module is approximately 33 ft (10 m) long, 13.8 ft (4.2 m) in diameter (Figure 2-10). As a multipurpose research and development laboratory, it provides a shirt-sleeve environment for astronauts and is equipped with power supply, thermal control, environmental control and life support, and data handling systems. The Exposed Facility (EF) is accessible through an airlock at the rear of the module.

A Remote Manipulator System (RMS) is capable of transferring payloads between the JEM and the Exposed Facility, as well as translating and rotating payloads under the remote control of a crew member in the pressurized module.

The Experiment Logistics Module (ELM) consists of two sections, one pressurized and one exposed. A 13.5 ft (4.1 m) long pressurized ELM (ELM-PS) section, 13.8 ft (4.2 m) in diameter, attaches to the JEM pressurized module. The pressurized ELM stores consumable goods and other pressurized cargo. It can be removed, sent to Earth for resupply, returned to the JEM pressurized module and reattached. The exposed ELM section (ELM-ES) is a box structure approximately 10.8 ft (3.3 m) high, 14.4 ft (4.4 m) wide and 7.2 ft (2.2 m) long. It is attached to the aft of the Exposed Facility.

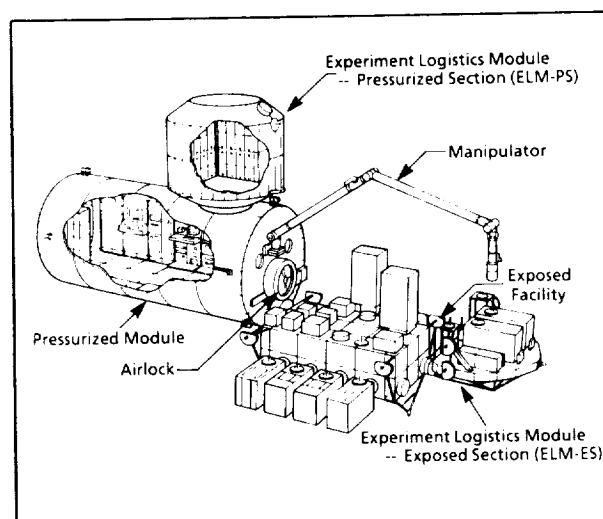


Figure 2-10 Japanese Experiment Module, Logistics Module and Exposed Facility

The ESA Attached Pressurized Module (APM)

The ESA Attached Pressurized Module (Figure 2-11), is approximately 38.7 ft (11.8 m) long and 14.7 ft (4.5 m) in diameter. It provides a shirt-sleeve environment for astronauts, and is equipped with power supply, thermal control, environmental control and life support, and data handling systems.

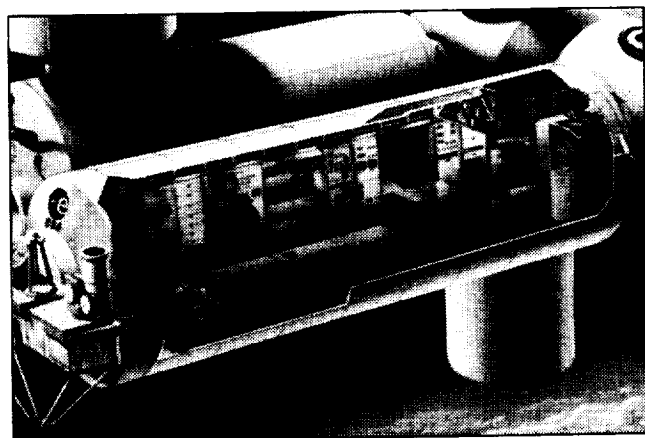


Figure 2-11 ESA Attached Pressurized Module

The entire module houses these systems and user payloads. Equipment and experiment racks are installed inside the module's floor, ceiling, and port and starboard walls.

The laboratory is designed to accommodate scientific or technological research principally in the disciplines of materials science, fluid sciences and life sciences.

ESA plans to provide an external viewing platform for attached payloads at the aft end of the APM.

Resource Nodes

Two pressurized resource nodes connect the pressurized modules and contain key controls for Station operation. Node 1 connects the U.S. Laboratory and the JEM. Node 1 also has ports for access to the pressurized logistics module, the Assured Crew Return Vehicle (ACRV) and the Centrifuge Accommodation Node. Node 2 connects the Habitation Module and the ESA APM, and has ports for access to the airlock, pressurized logistics module, cupola and Node 1.

Centrifuge Accommodation Node

The Centrifuge Accommodation Node, (Figure 2-13) is located at the starboard port of Resource Node 1. The node, scheduled to be launched on the first Shuttle flight following PMC, contains a 8.2 ft (2.5 m)

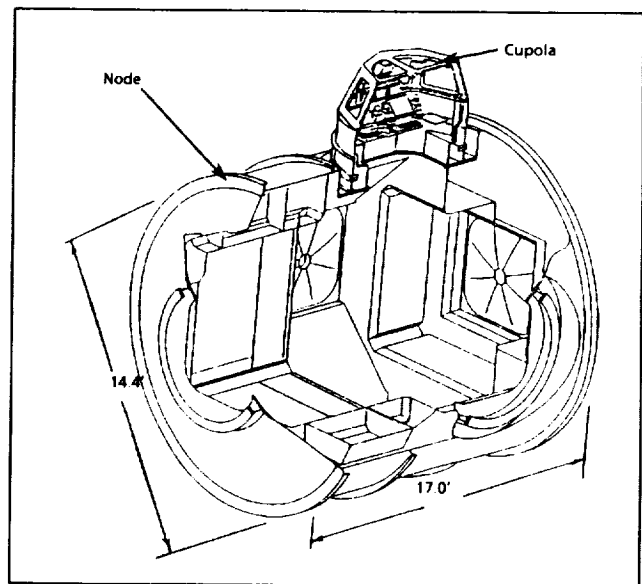


Figure 2-12 Resource Node with Cupola

diameter centrifuge, habitat holding units and a life sciences glovebox. The Centrifuge has room for several modular habitats and provides gravity levels ranging from 0.01 to 2 g's.

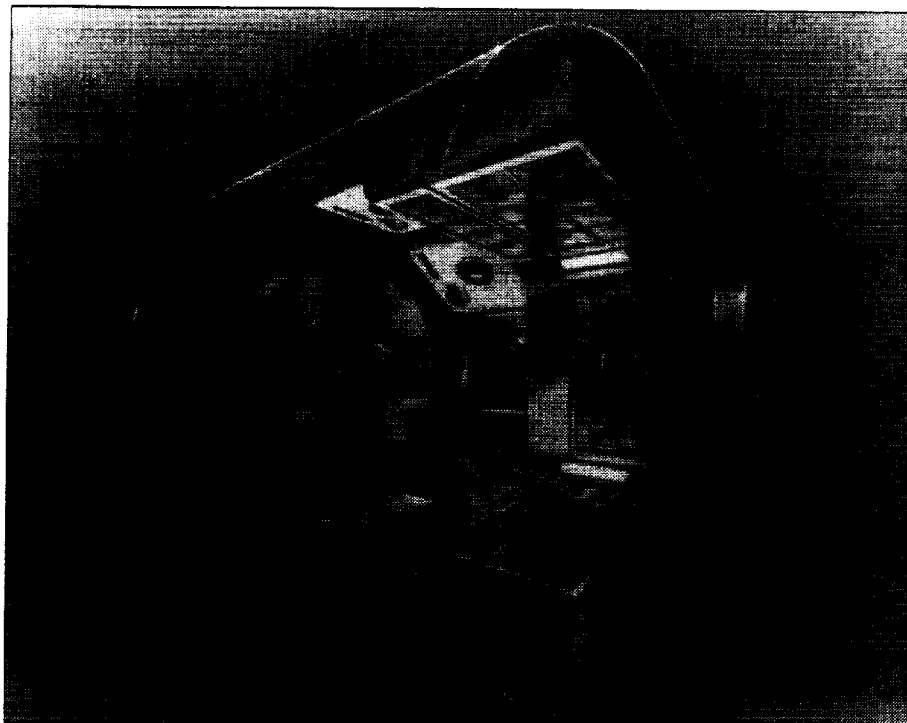


Figure 2-13 Centrifuge Accommodation Node

Cupola

The cupola is attached to the port side of Node 2. From the cupola, the crew members have a 360° field of view in azimuth and a complete hemispheric field of view in elevation. It can be used for observations and control of attached payload servicing.

Pressurized Logistics Modules (PLM)

Two distinct pressurized logistics modules are to be used at different stages of Freedom's growth. A mini-PLM (MPLM) is scheduled to support the Station commencing with the first utilization flight in 1997. A second MPLM will be launched later in 1997. Three PLMs will be added after PMC.

The PLMs are equipped with the resources needed to augment Freedom's pressurized working volume during the on-orbit working period. Both the MPLM and the PLM are equipped with environmental and thermal control, data management, power and capability for internal audio/video systems.

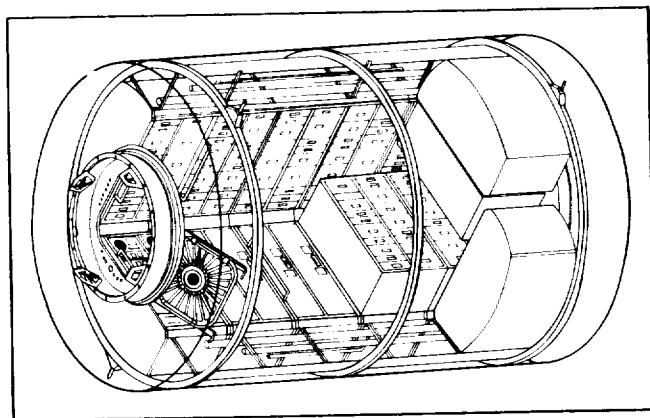


Figure 2-14 Pressurized Logistics Module

The MPLM is a cylinder approximately 14.5 ft. (4.4 m) in diameter and 11.0 ft. (3.4 m) long. It can accommodate seven user racks and a total payload mass of approximately 10,500 lbs. (4800 kg). The PLM (Figure 2-14) is also a cylinder approximately 14.5 ft. (4.4 m) in diameter and 22.0 ft. (6.7 m) long. It can accommodate twenty racks and a total payload mass of approximately 16,500 lbs. (7,500 kg).

Unpressurized Elements

The unpressurized elements of the manned base are:

- The Integrated Truss Assembly (ITA)
- The Mobile Servicing Center (MSC)
- JEM Exposed Facility
- The Unpressurized Logistics Carrier (ULC)

Integrated Truss Assembly (ITA)

The 353 ft (108 m) long ITA assembly is the structural framework for mounting the modules, logistics carriers, solar arrays and attached payloads. Distribution trays for the thermal control, power and data management systems are located on the ITA, along with utility ports and attachment mechanisms for payloads.

Mobile Servicing Center (MSC)

Canada's Mobile Servicing System (MSS) and the U.S. Mobile Transporter (MT) comprise the Mobile Servicing Center (MSC) (Figure 2-15). The MSC is used to remove attached payloads from the Space Shuttle's cargo bay and to transport them to appropriate locations on the truss. The MSC is also used to maintain and service attached payloads and to return them to the Shuttle's cargo bay when their missions are completed.

A Remote Manipulator System (RMS), approximately 58 ft (17.6 m) long with a payload capacity of 128 tons (116 metric tons), performs gross manipulations. A Special Purpose Dexterous Manipulator (SPDM) with two arms, each two meters long, is used to perform delicate tasks, such as connecting and disconnecting utilities and exchanging small hardware items. Onboard cameras provide the visual data the system needs to recognize, automatically track, and handle various objects.

The MSC can be operated from internal stations by the crew using hand controllers. It can provide power and data services to attached payloads while transporting them, and has lighting and video capabilities to facilitate inspection and handling.

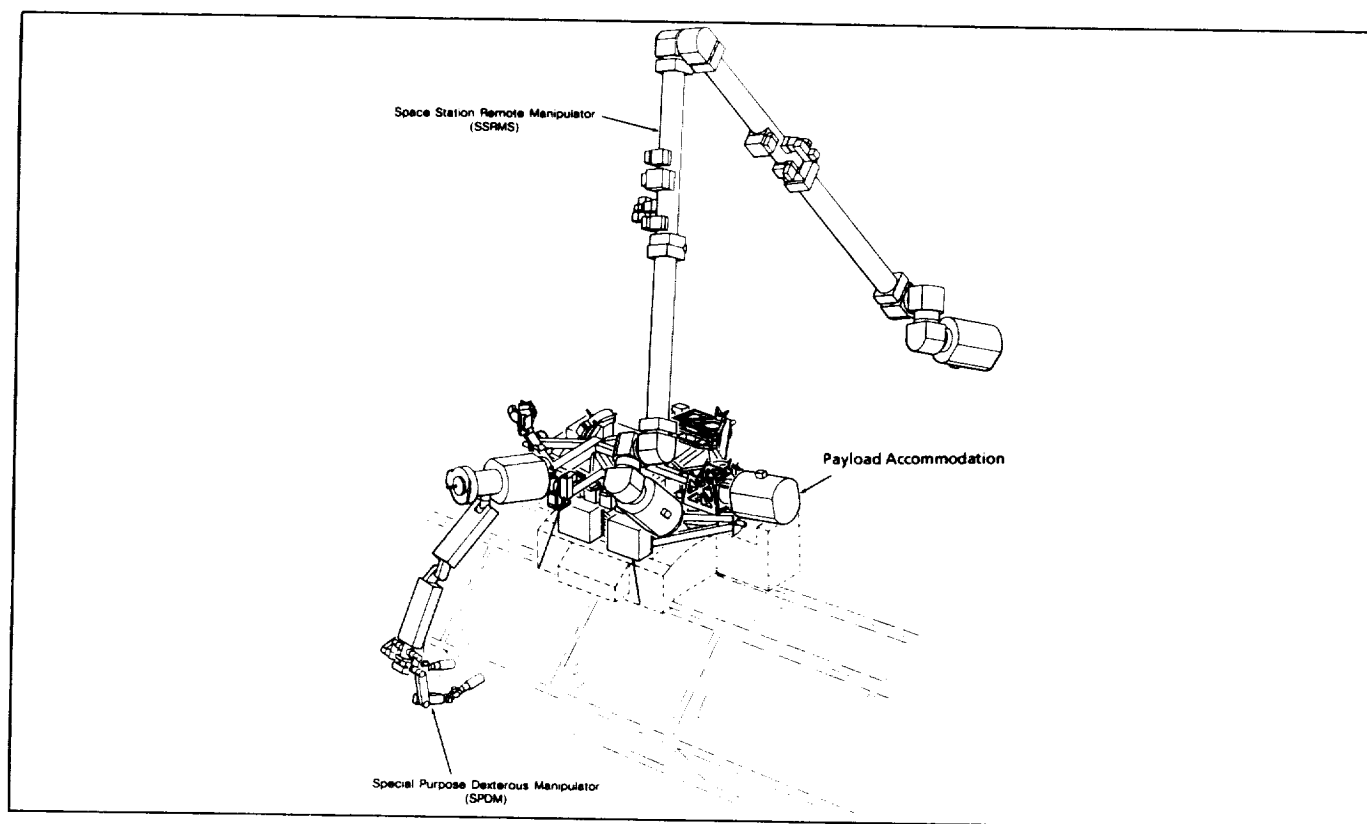


Figure 2-15 Mobile Servicing Center

JEM Exposed Facility

The JEM Exposed Facility (Figure 2-10) is a 16.4 ft (5.0 m) long unpressurized facility for scientific observations, communications and experiments requiring exposure to the space environment. It is located at the rear of the JEM and is connected by an airlock. The JEM RMS is used to transfer payloads between the pressurized module and the exposed facility.

Unpressurized Logistics Carrier (ULC)

The ULC (Figure 2-16) is outfitted to carry payloads oxygen, fluids and dry cargo, both containerized and noncontainerized. It is about 15.5 ft. (4.7 m) long, 13.5 ft. (4.1 m) wide and 8.5 ft. (2.6 m) high. The ULC has oxygen, fluids, and dry cargo subcarriers to accommodate both nonhazardous and hazardous items.

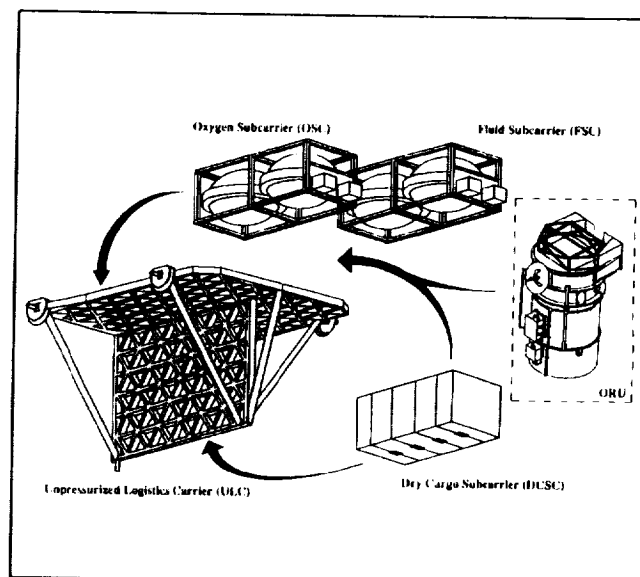


Figure 2-16 Unpressurized Logistics Carrier

Baseline Distributed Systems

The Space Station has the following distributed systems:

- The Data Management System (DMS)
- The Communications and Tracking (C&T) System
- The Electrical Power System (EPS)
- The Thermal Control System (TCS)
- The Guidance, Navigation and Control (GN&C) System
- Manned Systems
- The Environmental Control and Life Support System (ECLSS) and,
- The Propulsion System

A summary of these systems and the resources which they provide to users is presented below.

Data Management System (DMS)

As the "brain" of Space Station Freedom, the DMS monitors all aspects of the Station's operation (power, thermal, environmental control and life support, payload commands and communications, etc.). The DMS provides payload and systems data to the crew and to personnel on Earth via the NASA Tracking and Data Relay Satellite (TDRS) communications and tracking system.

DMS Hardware

DMS hardware includes data processors, control and monitoring workstations, data acquisition and distribution networks, and interface devices to systems and payloads.

The data distribution architecture of the DMS relies heavily on network technology and is composed of three major components: local area networks (LANs), one for systems and one for payloads; local data buses (1553 in U.S. Lab, 802.4 in APM and JEM); and high rate links (HRLs). Figure 2-17 illustrates the DMS network architecture. Figure 2-18 depicts the various DMS interfaces available to U.S. payloads.

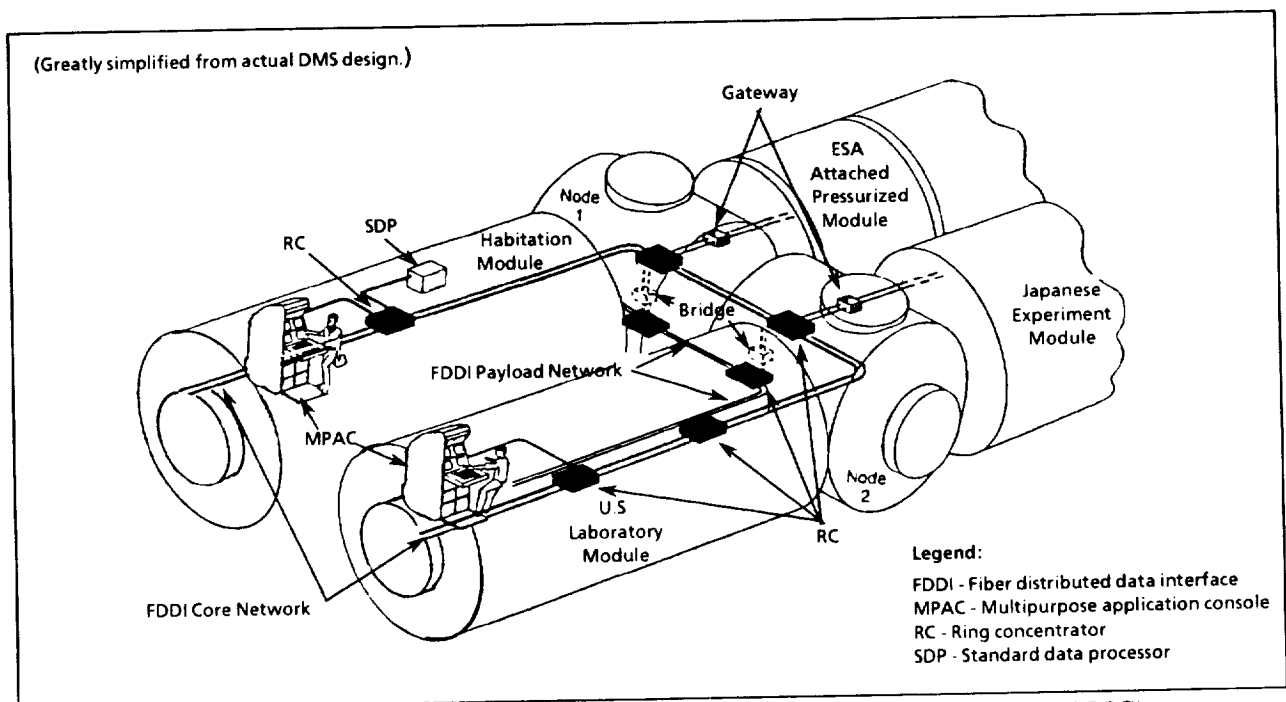


Figure 2-17 U.S. Laboratory Data Management System Networks (PMC)

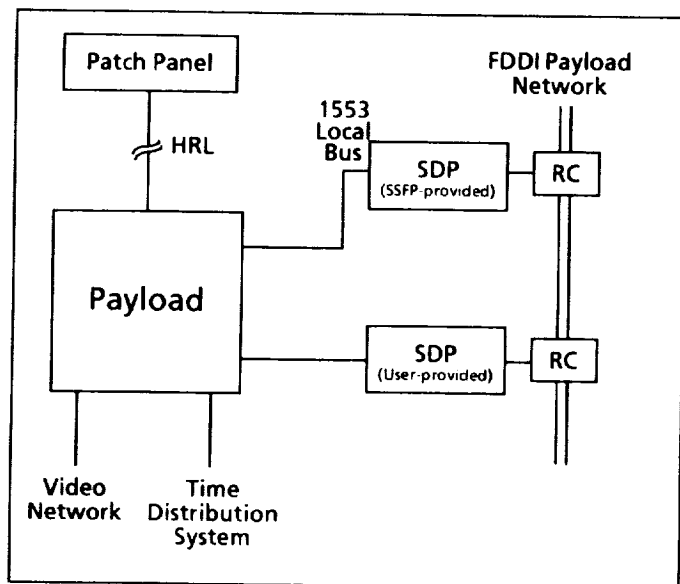


Figure 2-18 Example of Available U.S. Payload/DMS Interfaces

| Network/Link | Medium | Data Rate (per interface) | Data Rate (aggregate throughput, including overhead) |
|---------------|----------------------------|---------------------------|--|
| LAN 1553 bus | twisted shielded pair wire | 250 kbps | < 1 Mbps |
| LAN 802.4 bus | TBD | 1 Mbps | 10 Mbps |
| FDDI Payload | optical fiber | 10 Mbps | 100 Mbps |
| HRL | optical fiber | 100 Mbps | -- |

Table 2-2 Payload Data Interfaces

Table 2-2 summarizes the DMS resources available to payloads.

Local Area Networks

The DMS includes two LANs that conform to optical fiber distributed data interface (FDDI) standards. At MTC, FDDI system and payload networks will be provided throughout the Station to link all system and payload data units. The networks will be extended as the Station matures. System and payload networks are routed through both nodes, the U.S. Laboratory Module, and the JEM and ESA APM. Two bridges allow data communication between the system and payload networks. The FDDI can transfer data at a rate of 10 Mbps per interface with an upper limit of 100 Mbps aggregate throughput, minus overhead. Available bandwidth on the downlink limits total station payload transmissions to 43 Mbps, however. Access to the FDDI is facilitated by Ring Concentrators (RCs), which are distributed throughout the Station to permit interconnection of Standard Data Processors (SDPs), Mass Storage Units (MSUs) and Gateways.

Local Buses

A MIL-STD 1553 data bus using copper wires is available in the U.S. Laboratory Module at MTC. It has a data transfer rate capability of 250 kbps per interface. An IEEE 802.4 data bus is available in the JEM and APM. Gateways provide the interface between the FDDI payload network and the 802.4 buses. The 802.4 bus can transfer data at a rate of 1 Mbps per interface with a 10 Mbps aggregate throughput.

High Rate Links (HRLs)

HRLs bypass the DMS networks by interfacing with a manually configured patch panel to allow point-to-point data routing. HRLs can be used by a payload that has return data rate requirements that cannot be met by the payload LAN. HRLs are available only for payload downlink data and have a 100 Mbps data transfer rate capability to the patch panel. Once again, the available bandwidth on the downlink limits data transmission to 43 Mbps.

Standard Data Processor

A Standard Data Processor (SDP) is used to connect and control data transactions between some low data rate payloads and the payload LAN. Payloads that require data rates exceeding 250 kbps can be directly connected to the FDDI payload network by a user-provided SDP.

The SDP provided by the Space Station Freedom program is a Space Station resource that is controlled by the SSFP. User-provided software residing in the SSFP SDP can be scheduled to run concurrently with payload operation, subject to SSFP operations limitations.

Workstations and Video

Workstations, called Multipurpose Application Consoles (MPACs), are used by the crew to interface with the data system; monitor and control onboard systems; display video, and payload and system data; and communicate with the ground. Stationary MPACs are located in the pressurized modules, and compatible workstations provided by the SSFP partners are located in the JEM and the APM. An MPAC is also located in the cupola. All crew interfaces for the workstations are similar, and the data displayed on them can also be displayed on monitors on Earth.

Data Storage

DMS data is stored using Mass Storage Units (MSU) which are magnetic hard disks. One MSU is available for payload command and control software only.

Time Distribution System

A stable frequency reference and time reference is provided by the DMS time distribution system (TDS).

DMS Software

The DMS software resides in various software "nodes" that include the Standard Data Processors, the Multiplexer/Demultiplexer, the Mass Storage Unit and the Multipurpose Application Consoles.

The computer language used for software developed by the SSFP is Ada. Interfaces between the processing, communications and memory hardware and user

Ada applications are provided by the DMS Operating System/Ada Run Time Environment (OS/Ada RTE). All DMS processors that host applications use the OS/Ada RTE or a controlled subset of the software.

Payload users are able to develop and provide application software for the SDP. The interfaces for the software applications consist primarily of Standard Services and the OS/Ada RTE.

DMS Standard Services provides payloads and core systems with access to data communications, data acquisition and commanding and timing information. Payloads are required to use Standard Services for commands, and for any communications with LANs, including telemetry. Core Systems are required to use Ada for their applications unless Ada cannot meet performance or other unique requirements. Payloads are not explicitly required to use Ada.

Communications and Tracking (C&T) System

The C&T system provides the communications and tracking services to support Freedom's operational requirements. An overview of the C&T system is shown in Figure 2-19.

The C&T system provides audio and video capabilities and communications with the ground and other spacecraft. Data, video and audio may be transmitted to the ground from Freedom. Payload commands and audio – not video – may be transmitted from the ground to the Station. The downward or "return" data transmission capability via a Ku-band system is 43 Mbps. The upward or "forward" transmission capability via an S-band system from the ground is 72 kbps for Station systems and payload operations.

The Tracking and Data Relay Satellite System (TDRSS) is the primary Space Station data and communications link with the ground. Data and commands are transmitted to and from Freedom via TDRSS to White Sands, New Mexico. Distribution mechanisms for data received at White Sands are under development.

The TDRSS and the Station are in communication for most of the time except for a brief period known as the Zone of Exclusion (ZOE). This period averages approximately ten minutes during each orbit (Figure 2-20), but ranges from zero to 15 minutes.

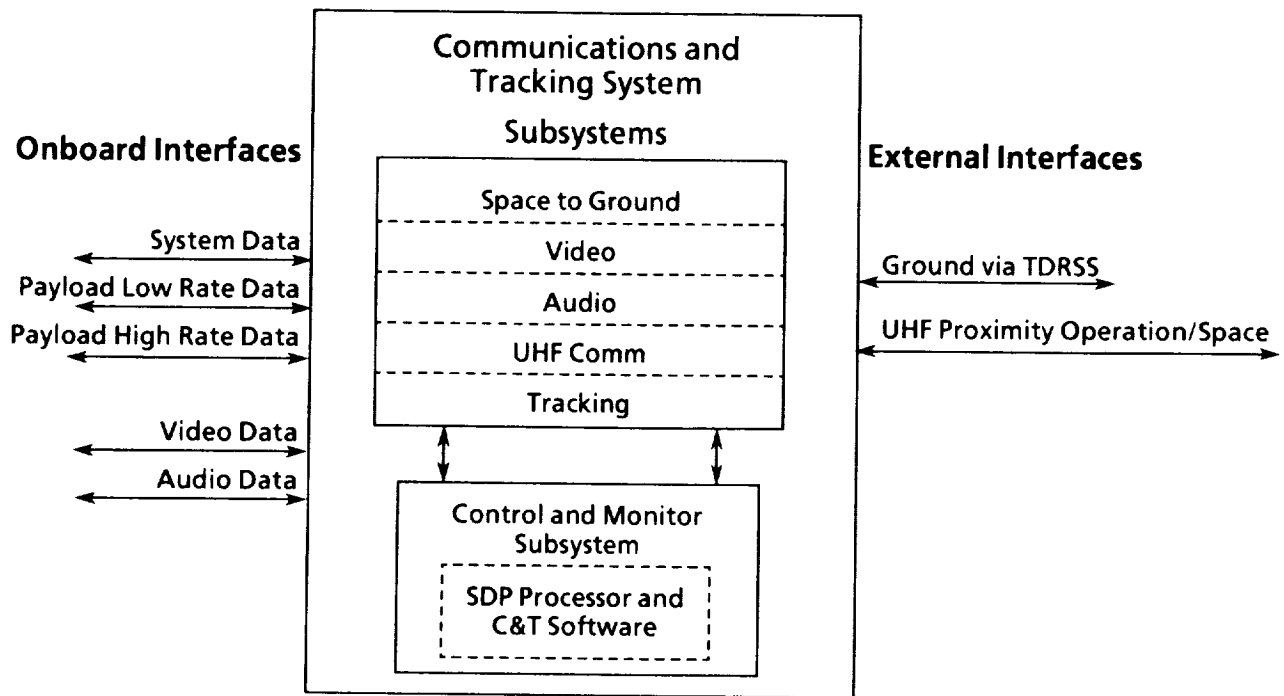


Figure 2-19 Communications and Tracking System Functional Block Diagram

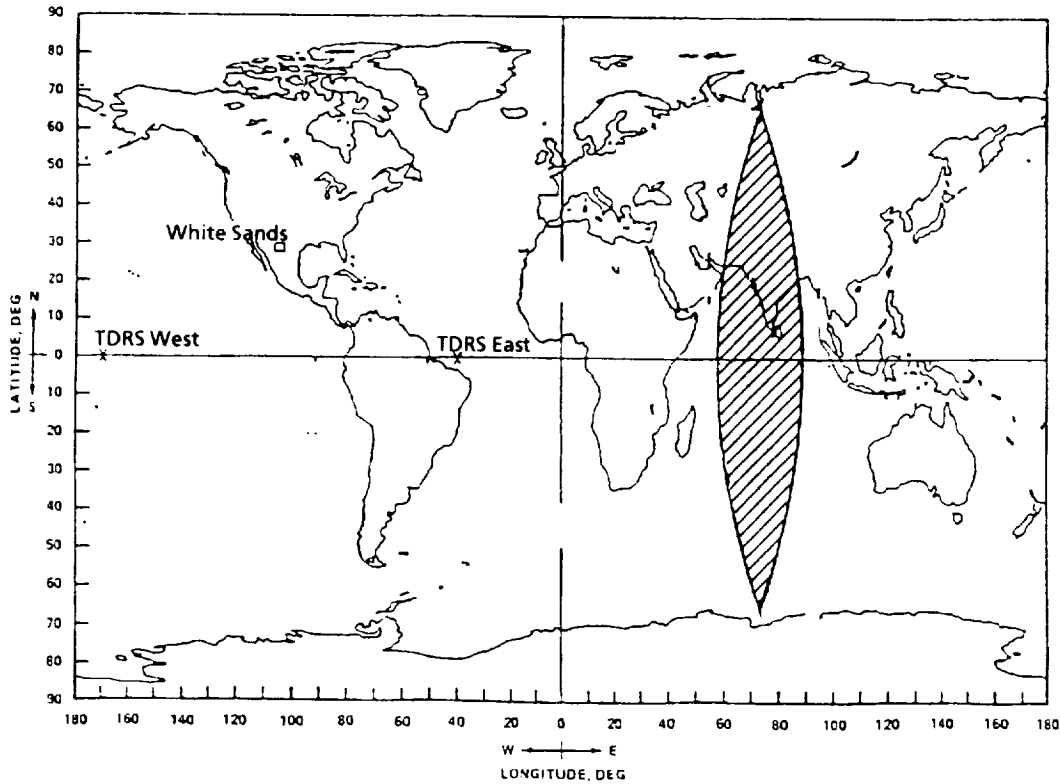


Figure 2-20 Zone of Exclusion

During this time, users are unable to receive data transmissions. There is also a very short period of disruption (on the order of two minutes during each orbit) when communications are being handed over from one TDRS to another.

The video subsystem uses cameras located within the elements and on the truss of Space Station Freedom. A video switching system allows images from any compatible or SSFP-supplied camera to be displayed on any monitor or MPAC workstation display. The video signal used onboard is Pulse Frequency Modulated Optical and compatible with the National Television System Committee standard. A video processor provides split screening and freeze frame capabilities.

The JEM and APM have video systems provided by their respective agencies. Each system is compatible with U.S. networks for onboard distribution and ground communications. Video and audio signals are digitized, assembled into data transfer frames (packets), and multiplexed with DMS data for Ku-band downlink transmission. Video, audio and data signals have time synchronization for proper time stamping and voice/data correlation.

Electrical Power System (EPS)

At PMC, a series of three solar array wings generate power onboard Freedom. Nickel-hydrogen batteries store the dc power generated by the solar arrays for use when the station is in the shadow of Earth.

The EPS generates 18.75 kW of orbital average power at MTC, which increases to 56.25 kW at PMC. At least 11 kW are available to users at MTC while 30 kW are nominally available for user operations at PMC. The EPS provides 120 volt dc power to the user interface.

Thermal Control System (TCS)

The TCS maintains the Space Station's structure, systems, equipment and payloads within their allowable temperature ranges. A two-phase ammonia system acquires heat from heat acquisition devices in the pressurized modules and transports it to two radiators located on the transverse boom.

At MTC, two low temperature (32° F) loops will provide an average of 13 kW cooling to payloads in the U.S. Laboratory Module. At PMC, a moderate temperature (67° F) loop will also be available, bringing the total cooling capacity for payloads to 30 kW.

Researchers must provide their own independent thermal control for attached payloads mounted on the truss.

Guidance, Navigation and Control (GN&C) System

The GN&C system maintains attitude control and the proper orbit, and accurately determines pointing angles. Attitude control is necessary to maintain the proper microgravity environment for experiments. In conjunction with the propulsion system, it controls reboost and rendezvous operations. Knowledge of the Space Station's inertial attitude is accurate within one degree and is available to researchers as required. The GN&C system allows researchers to determine Freedom's exact orbital speed, attitude and altitude at all times.

Under normal operating conditions, the GN&C system limits the maximum attitude variation to 2.5 deg/axis/orbit. It also provides an estimate of orbital position within ± 656 ft (200 m) and the orbital velocity within ± 1 ft/sec (0.3 m/sec).

Manned Systems

Manned systems provide the crew with a safe environment and the necessities of life. The Crew Health Care System (CHCS) is comprised of the Health Maintenance Facility (HMF), the Exercise Countermeasure Facility (ECF) and the Environmental Health System (EHS). The HMF includes test and diagnostic instruments, a patient restraint and medical provisions to stabilize an injury or illness.

The ECF includes exercise and monitoring equipment to counteract musculoskeletal and cardiovascular deconditioning. The EHS monitors Freedom's internal environment and includes instruments for microbiological, toxicological, radiation, and acoustics measurements. A computerized system keeps track of medical supplies, crew condition and checkup

schedules. CHeCS interfaces with the DMS to provide for onboard data display and transmission to the ground.

Environmental Control and Life Support System (ECLSS)

The ECLSS provides a comfortable environment throughout the pressurized modules. Temperature, humidity, air composition and atmospheric pressure are maintained, as well as nitrogen, potable and fuel cell water, and fire detection/suppression equipment. The ECLSS maintains an atmospheric pressure of 10.2 psia and an oxygen concentration of not more than 30 percent during MTC. Following PMC, a pressure of 14.7 psia and an oxygen concentration of not more than 23.8 percent are maintained. However, the atmospheric pressure may be increased to 14.7 psia and the oxygen concentration reduced to 23.8 percent during MTC, except during MB flights, to fulfill the needs of researchers.

Propulsion System

A hydrazine-fueled propulsion system keeps Freedom at a safe altitude. Because atmospheric drag forces gradually reduce Freedom's altitude, it must be periodically reboosted by the propulsion system to a higher altitude. The propulsion modules are mounted on the truss.

Information Services

The SSFP is responsible for coordinating the diverse data gathering, communication, handling and processing systems associated with the Space Station. Among the services most relevant to the researcher are: command and control services, payload researcher support services and automated information security services.

Command and control services provide for the interactive control and monitoring of payloads, elements and systems, as well as for the collection, transmission, processing, storage and exchange of data among ground-based operators and researchers.

Payload researcher support services are those that enable productive researcher operations and support useful payload data. Using telescience, an example of one of these services, researchers can access remote experiments and databases interactively in pursuit of

their experimental objectives. One aspect of telescience is the capability for researchers, at their home institutions, to control and monitor payloads in space. Transparent data communications is another of the payload researcher support services. The SSFP delivers data to the researcher in the form in which it was generated by the researcher's payload. The interoperability and ease of interface among data systems is included among these services.

The handling and provision of ancillary data necessary for the meaningful processing of researcher payload data is another service. Ancillary data comprises orbital position, attitude references, capability to compute pointing references in real time, standard time references and a record of Station events (e.g., thruster firings, venting, MSS operation, etc.).

Automated information security services are those that control access to the information network and ensure the integrity of the data traversing it on an end-to-end basis. It is important to note that the SSFP does not provide data encryption services for researcher payload data. The researcher may encrypt payload data as necessary.

Environment

The *natural* environment is the environment as it exists unperturbed by the presence of the Space Station. The *induced* environment is the environment that exists as a result of the presence of the Space Station. Researchers should be aware of the potential effects the two environments can have on payloads.

Natural Environment

The natural environment includes:

- The Neutral Atmosphere
- Plasma
- Charged Particle Radiation
- Electromagnetic Radiation (EMR)
- Meteoroids
- Space Debris

The Neutral Atmosphere

The neutral atmosphere is significant for Space Station operations for two reasons. First, it produces torques and drag that degrade Freedom's altitude. Second, it affects the flux of trapped radiation the Station encounters.

Plasma

Plasma is important to Space Station operations because it controls the extent of spacecraft charging, affects the propagation of electromagnetic waves such as radio frequency signals, and probably contributes to surface erosion. Another important effect is the production of electric fields in the structure as the Station moves across the geomagnetic field.

Charged Particle Radiation

Many of the charged particles have sufficient energy to penetrate several centimeters of metal and to produce significant levels of ionized radiation inside. A high level of radiation can significantly affect materials, chemical processes and living organisms, especially the crew. It can also affect electronics by causing soft upsets and Single Event Upsets (SEUs), degrading performance or producing permanent damage. In addition, it can affect the propagation of light through optical materials by altering their optical properties.

Electromagnetic Radiation (EMR)

Freedom's systems and payloads are bathed in electromagnetic radiation of all frequencies while in orbit. EMR comes from Earth, from plasmas surrounding Earth, from the Sun and the stars, and from the nearby ionosphere, disrupted by the passage of the Space Station itself. Intense EMR can affect Freedom's systems or payloads.

Micrometeoroids and Space Debris

During its lifetime the Space Station will encounter both micrometeoroids and space debris. Because either type of object can damage the Station itself or its attached payloads, critical Station elements are protected by a combination of shielding and shadowing.

Induced Environment

Internal

Space Station Freedom provides an environment suitable for the performance of microgravity experiments. Acceleration levels of $10^{-6}g$ or less, at frequencies ≤ 0.1 Hz, are maintained for at least 50 percent of the user accommodation locations for continuous periods of 30 days or more beginning at MTC and continuing thereafter. These conditions are provided for at least 180 days per year. For frequencies between 0.1 and 100 Hz, the acceleration levels are less than the product of $1 \times 10^{-5}g/Hz$ and the frequency. Acceleration levels of $\leq 1 \times 10^{-3}g$ are provided for frequencies exceeding 100 Hz. Figures 2-21 and 2-22 depict the quasi-steady microgravity acceleration contours at MTC and PMC, respectively. However, the microgravity environment is affected by the operation of the Space Station. The use of control moment gyroscopes for attitude control during normal operations minimizes vibrational disturbances. The greatest disturbances ($\sim 10^{-3}g$) occur during Shuttle docking and Station reboost.

An Acceleration Mapping System (AMS) is provided in the U.S. Laboratory Module at MTC. The AMS consists of a system of fixed accelerometers to measure quasi-steady acceleration (frequency < 0.01 Hz) and movable accelerometers to measure vibration between 0.01 and 300 Hz. Information characterizing the acceleration environment is routinely available in a timely manner to researchers and crew to support payload operations and post-flight data analysis.

Quiescent and nonquiescent periods are scheduled in advance. During quiescent periods, which are maintained for at least 30 days, optimum microgravity conditions are provided. During nonquiescent periods, such as during Station reboost, the disturbed environment may be unacceptable for the operation of some payloads.

External

The presence, operation and motion of the Space Station will affect the surrounding environment. Some of the known induced effects are:

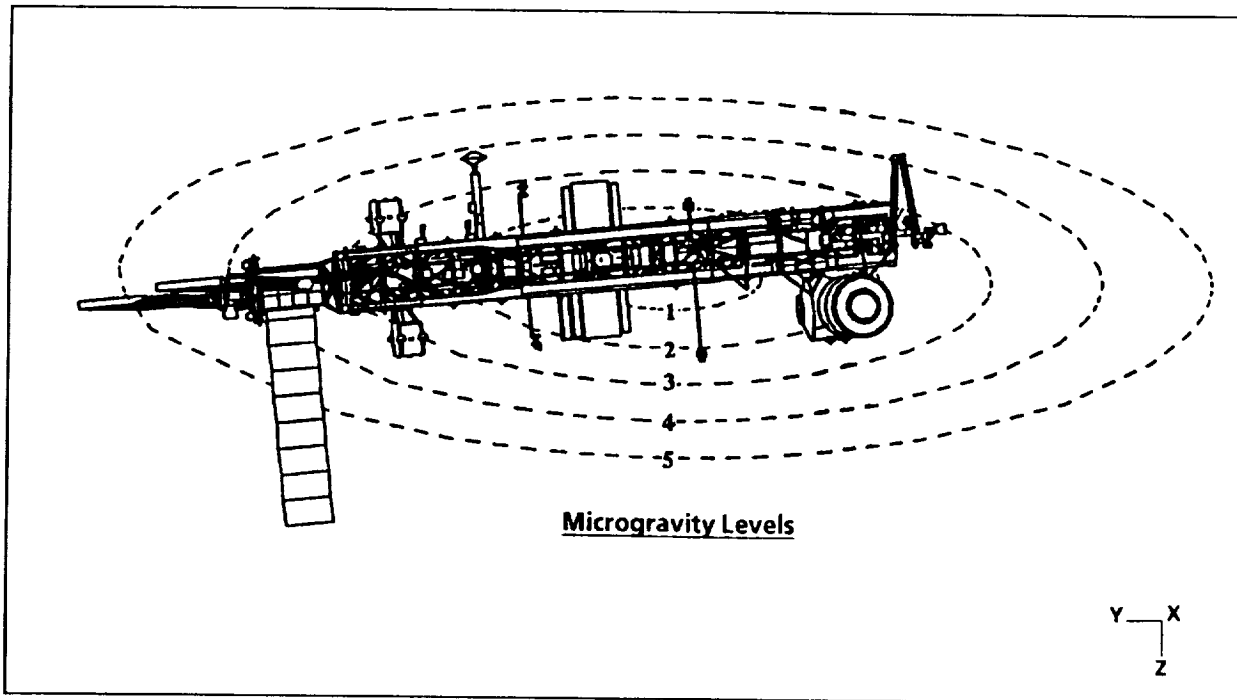


Figure 2-21 Microgravity Quasi-Steady Accelerations at MTC

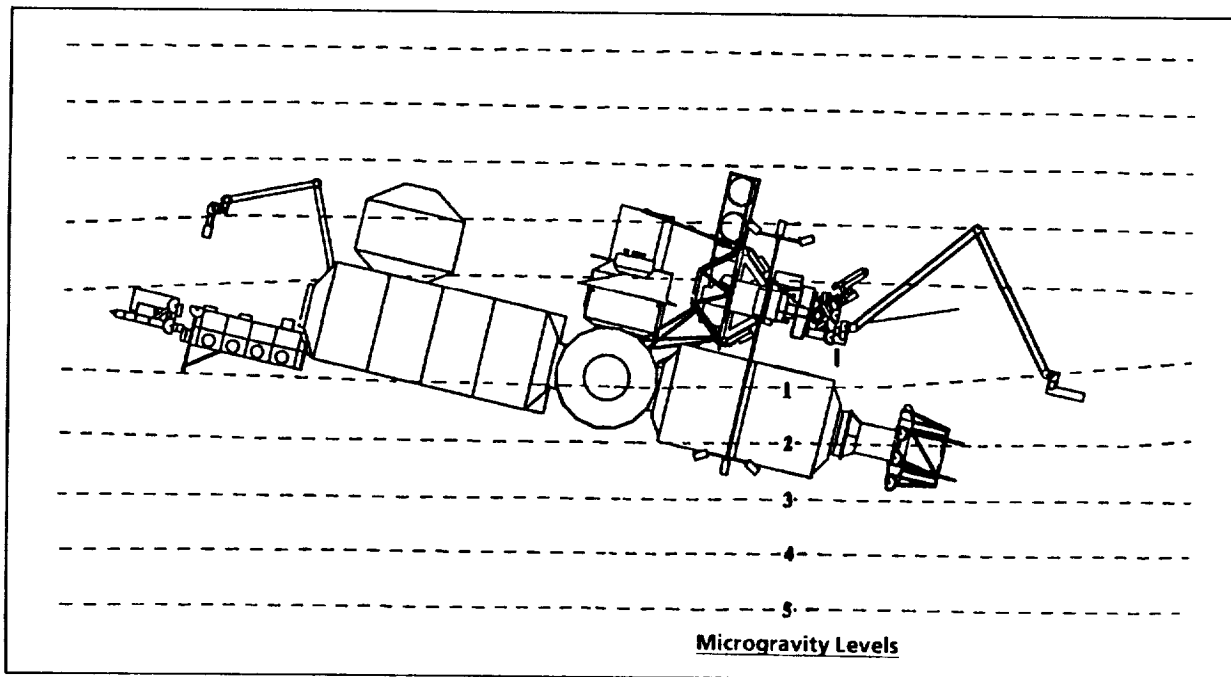


Figure 2-22 Microgravity Quasi-Steady Accelerations at PMC

-
- Plasma wake - the variation of plasma density from the ram to the wake side.
 - Neutral wake - the variation of neutral density
 - Plasma waves induced by the Station's motion
 - Vehicle glow on the ram or forward side
 - Change of local plasma density and production of electrical noise caused by spacecraft charging
 - Enhancement of neutral density and change of neutral composition by outgassing, offgassing, and the plumes from thrusters
 - Emission of conducted and radiated electromagnetic power by systems on the Station
 - Deliberate perturbation of the environment by active experiments and devices such as
 - ▶ Transmitters/wave injectors
 - ▶ Particle beam emitters
 - ▶ Plasma emitters
 - ▶ Chemical releases
 - ▶ Laser beams
 - Visible light generated by the Station and reflections from it
 - Induced currents and voltage potential difference that are generated by the motion of the Station through Earth's magnetic field, which can draw current through the surrounding plasma.

3. PAYLOAD ACCOMMODATIONS

Space Station Freedom researchers may place payloads in racks within the pressurized laboratory modules, at ports on the truss, on the JEM Exposed Facility or on the ESA APM's external viewing platform. Payloads within the pressurized modules are transported to or from the Station in the Shuttle's cargo bay by means of the Pressurized Logistics Module (PLM) and MPLM. Attached payloads are placed directly into the Shuttle's cargo bay for transport to or from the Station. Table 3-1 summarizes the accommodations that are available to researchers.

International Standard Payload Rack (ISPR)

The basic accommodation for payloads in the pressurized modules is the ISPR. The U.S. Laboratory Module has 12 ISPR locations available for researcher accommodations. In addition, three systems racks

are available to researchers prior to delivery of the Habitation Module, which occurs just before PMC. The APM contains 20 ISPRs for researchers, plus one non-ISPR. The JEM has 11 racks for researchers; ten are ISPRs and one is for storage. About nine ISPRs in the APM and about five in the JEM are available to NASA-sponsored researchers.

Basic utilities are provided at all ISPR locations. Additional utilities are provided to certain ISPR locations in each module.

The ISPR location and attachment features are common throughout the pressurized elements, thereby allowing the interchange of standard racks within and among the three international laboratories. This allows on-orbit reconfiguration of the laboratories with researcher equipment routinely integrated and deintegrated as researcher requirements dictate.

| Accommodation Element | Number of International Standard Payload Racks for NASA Sponsored Payloads | Number of External Locations for NASA Sponsored Payloads | Power Provided (120 V dc) | Thermal Control |
|---------------------------------|---|---|------------------------------|-----------------|
| Pressurized | | | | |
| U.S. Laboratory Module | 11.5 | N/A | 3, 6, 12 kW | 3, 6, 12 kW |
| ESA Attached Pressurized Module | 9 | N/A | 1 5, 3, 6 kW | TBD |
| Japanese Experiment Module | 5 | N/A | 3, 6 kW | 3, 6 kW |
| Unpressurized | | | | |
| Truss | N/A | 2 ports @ MTC 4 ports @ PMC | 6 kW (Total) | N/A |
| ESA External Viewing Platform | N/A | TBD | 3kW (Total) | N/A |
| JEM Exposed Facility | N/A | 4 | 10 kW (Total) | 11 kW (Total) |

Table 3-1 Summary of Space Station Freedom Accommodations

Front, side and back panels of the ISPR may be removed for maintenance. The racks have standard interface plates with utility cutouts located at the base of the racks. All rack utility connections other than avionics air pass through a panel located at the bottom front corner of the rack. This allows the rack to be tilted out for servicing and maintenance without disconnecting utilities, and to remain active while it is tilted out (Figure 3-1).

Dimensions and Resources

The outer dimensions of the ISPR are 80 in. (2.0 m) high, 42 in. (107 cm) deep, and 42 in. (107 cm) wide (Figure 3-2). Payloads may be accommodated in

standard 19 in. (48 cm) drawers or double width drawers. The Space Station resources available to the ISPRs are summarized in Table 3-1.

Utilities

Table 3-2 summarizes the utilities available to laboratory payloads at MTC and PMC, respectively. The basic utilities provided to each rack location are power, video, fire detection and suppression, time, avionics air, and high-rate data.

Utilities provided at selected locations are thermal control, vacuum resource, vacuum exhaust, gaseous

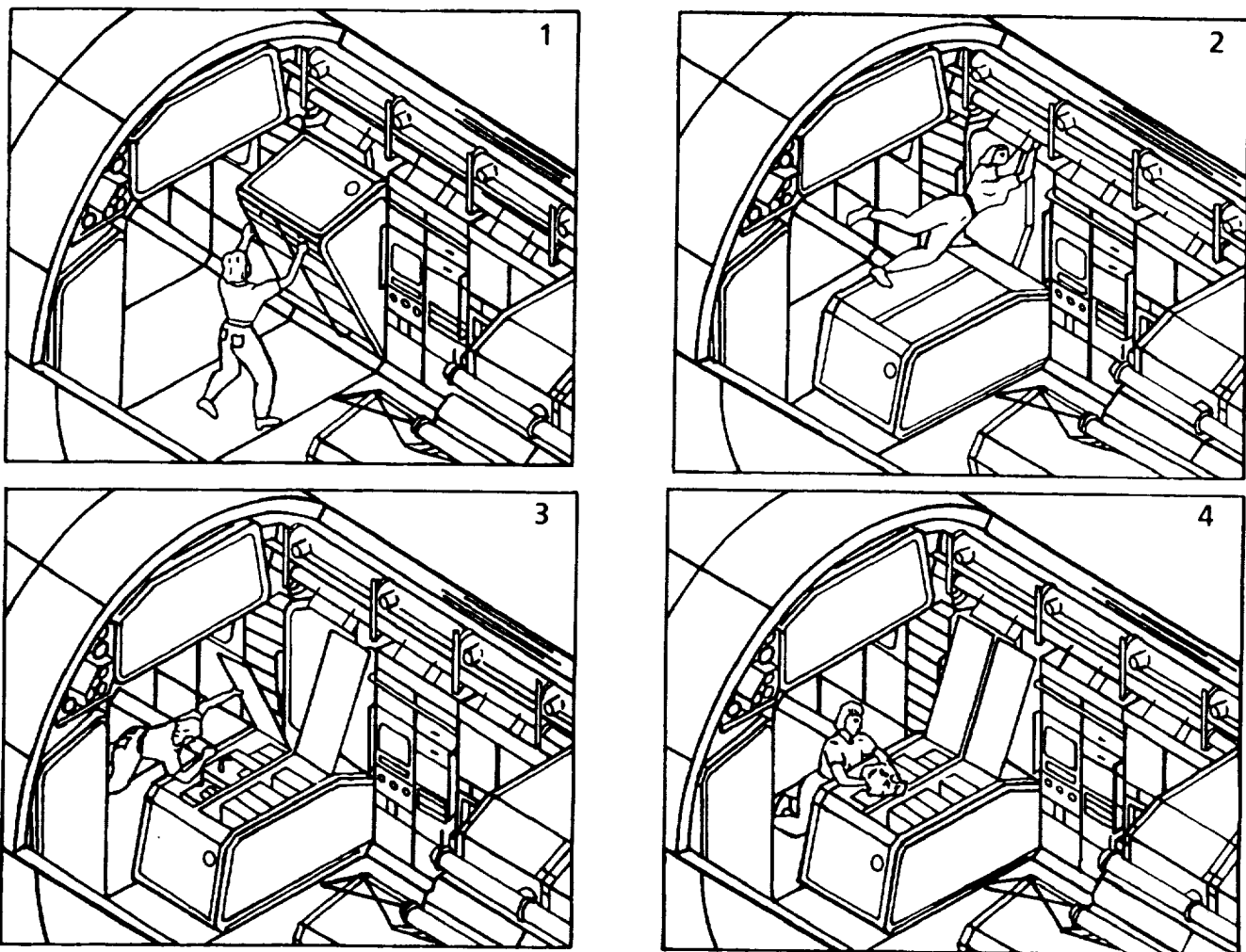


Figure 3-1 Tilt Out Capability of the ISPR

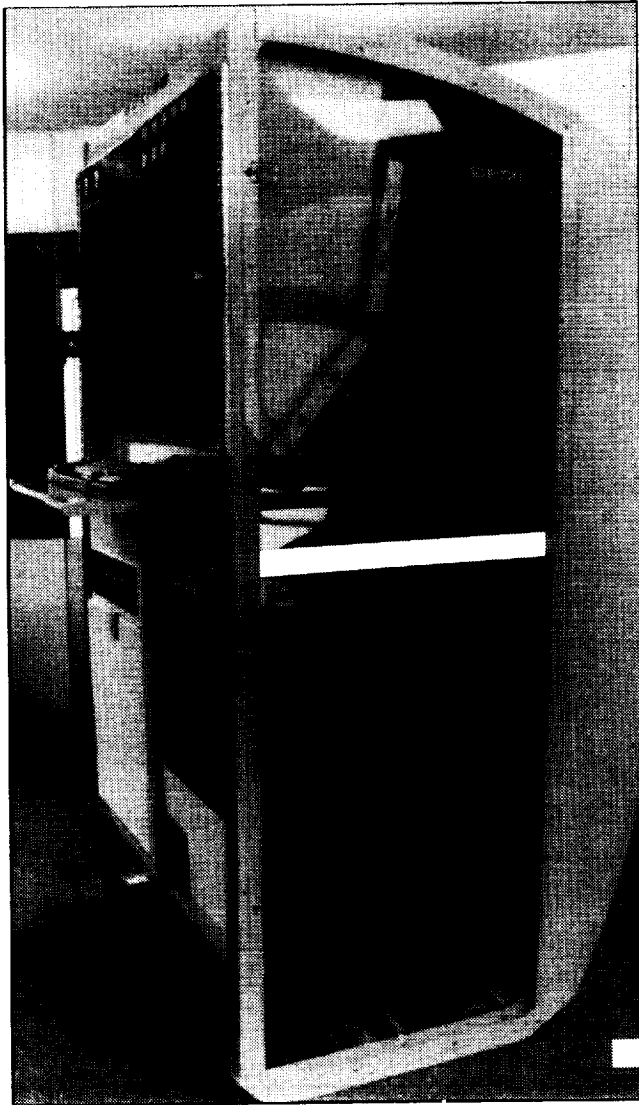


Figure 3-2 An ISPR

nitrogen, direct access to a fiber distributed data network, and low-rate data access to local buses.

The rack utilities discussed below interface with the rack at the utility interface panel. A description of the systems providing these utilities can be found in the preceding section entitled Space Station Freedom Description.

Electrical Power System (EPS)

The EPS provides all researcher and housekeeping electrical power. The EPS generates 18.75 kW of orbital average power at MTC and 56.25 kW at PMC. At MTC at least 11 kW is available for payload

operations. At PMC, at least 30 kW is available. The power supply is available with 1.5, 3.0 or 6.0 kW capability depending upon the rack location. Some ISPRs with dual 6 kW inputs can provide 12 kW to payloads. The EPS provides 120 volt dc power to the payload interface.

Data Management System (DMS)

The DMS is an onboard, networked, computer system. Commands and data are transmitted to and from user payloads via the DMS. The DMS includes all the hardware and software required for data processing and local communications among the onboard elements, systems and payloads. The DMS also provides for the operation and control of Space Station Freedom. DMS data can be transferred via the payload LAN or a local bus.

Each ISPR also has access to a high-rate link that bypasses the DMS networks, via a patch panel. The patch panel can connect the rack directly to the C&T System for transmission of return link data at 43 Mbps. The payload must provide the electronics needed to interface with the high-rate links.

Time Distribution System (TDS)

Time distribution is provided through a dedicated connector on the utility interface panel.

Thermal Control System (TCS)

The TCS maintains structures, systems, subsystems, equipment and payloads within required temperature ranges. Two liquid coolant loops are available at many of the ISPR locations (See Table 3-2). However, only one of the loops may be used at a given location. The TCS is capable of handling heat rejection loads of at least 12 kW at three ISPR locations, 6 kW at three ISPR locations, and 3 kW at all other ISPR locations in the U.S. Laboratory Module; and 3 kW at six ISPR locations and 6 kW at four ISPR locations in the JEM.

Avionics Air

Avionics air cooling is provided to all ISPR locations. It has at least 1.2 kW heat rejection capability to each ISPR location. The total avionics air heat rejection capability for the ISPRs in the U.S. Laboratory Module is 3.6 kW.

| | Number of ISPR Locations Accommodated | | | |
|---|---------------------------------------|------------------------|----------------------|-----------------------|
| | at MTC | at PMC | | |
| | U.S. Lab (12 Total) | U.S. Lab (12 Total) | JEM-PM (10 Total) | ESA APM (20 Total) |
| Electrical Power System | | | | |
| 1.5 kW | - | - | - | 6 |
| 3kW | 6 | 6 | 6 | 10 |
| 6 kW | 3 | 3 | 4 | 4 |
| 12 kW | 3 | 3 | - | - |
| Thermal Control System | | | | |
| Moderate Temperature Loop (67°F) | - | 12 | 10 | 14 |
| Low Temperature Loop (32°F) | 12 | 12 | 4 | - |
| ECLSS | | | | |
| Avionics Air | 12 | 12 | 10 | 20 |
| Fire Detection and Suppression | 12 | 12 | 10 | 20 |
| Gaseous Nitrogen | 12 | 12 | 10 | 14 |
| Data Management System | | | | |
| High-Rate Data | 12 | 12 | 10 | 20 |
| Low-Rate Data (1553 Bus) | 12 | 12 | - | - |
| 802.4 Bus | - | - | 10 | 20 |
| FDDI | 12 | 12 | 7 | 14 |
| Time | 12 | 12 | 10 | 20 |
| Communications & Tracking System | | | | |
| Video | 12 | 12 | 10 | 20 |
| Other | | | | |
| Vacuum Exhaust System | 12 | 12 | 10 | 14 |
| Vacuum Resource System | 12 | 12 | 6 | 14 |

Table 3-2 ISPR Capabilities at MTC and PMC

Communications and Tracking (C&T) Video Subsystem

Each ISPR has a single-video connector with three interfaces for input, output and synchronization and control. The video system accepts a National Television System Committee (NTSC) formatted signal. A payload may send video from inside the payload rack to an MPAC, a video monitor or a ground facility. A camera, which converts the signal to pulse frequency modulated optical and is compatible with the NTSC standard, is available for purchase from the SSFP.

Fire Detection and Suppression (FDS)

Fire detection and delivery of CO₂ for fire suppression is accomplished at the rack through the FDS connector on the utility interface panel. The FDS requires approximately 200 watts of air cooling in order to supply the air flow needed for fire detection at each ISPR. In addition to the FDS, portable CO₂ fire extinguishers can provide fire suppression through a separate Portable Fire Suppression Interface Panel access port on the rack.

Gaseous Nitrogen

A single gaseous nitrogen line is provided at selected ISPR locations.

Vacuum Resource System

A vacuum line capable of attaining and maintaining 10^{-3} torr for a single payload is provided at selected ISPR locations.

Vacuum Exhaust System

A waste gas vent line for the disposal of nontoxic and nonreactive gaseous payload waste is provided at selected ISPR locations. There is no on-orbit storage or treatment available. Researchers are responsible for the containment, storage and transport hardware required for gases that cannot be delivered to the vent line.

Liquids and solids cannot be vented or jettisoned and must be returned to the ground. Researchers are responsible for the containment, storage and transport hardware required for all payload-generated liquid and solid waste.

Water

The ISPRs are not plumbed for water distribution. Potable water is available for payloads at a spigot located in the U.S. Laboratory Module.

Laboratory Support Facilities and Equipment

General laboratory support facilities (GLSF) and laboratory support equipment (LSE) are available on Freedom for the benefit of researchers. A summary of these facilities and equipment is presented in Table 3-3.

Table 3-3 General Laboratory Support Facilities (GLSF) and Laboratory Support Equipment

General Laboratory Support Facilities

Materials Processing Glovebox
Life Sciences Glovebox (in Centrifuge Node)

Laboratory Support Equipment

Battery Charger
Cameras, Still and Video
Camera Locker
Cleaning Equipment
Digital Multimeter
Digital Recording Oscilloscope
Digital Thermometers
EM-Shielded Locker
Film Locker
Fluid Handling Tools
Freeze Drier
Freezer, -20°C
Freezer, -70°C
Freezer, Cryogenic (Quick/Snap and Storage)
General Purpose Hand Tools
Macroscopic, Stereo
Micromass Measurement Device
Passive Dosimeter
pH Meter
Portable Glovebox
Refrigerator
Specimen Labeling Device
Small Mass Measurement Device

Truss Attached Payloads

Space Station Freedom will provide accommodations for payloads to be attached to the truss assembly. Two locations will be provided at MTC, increasing to four locations at PMC (Figure 3-3).

Attached payloads will be able to face upward (zenith), Earth (nadir), forward of the Space Station (ram) or behind the Space Station (wake). Each attached payload site will have a mechanical attachment capability (Figure 3-4) for a single attached payload or a carrier of multiple attached payloads. Each site can provide a clearance envelope of at least 1,000 cubic feet (28 m³) and accommodate a payload mass of 5,000 lbs (2300 kg). Some sites can accommodate a payload mass of up to 10,000 lbs (4500 kg).

Power and data transmission ports will be provided to the sites. Each port will be capable of providing at least 3 kW peak power (120 Vdc) with 500 W of survival power. A maximum of 6 kW total power is available. A data transmission capability of up to 400 kbps downlink to Earth will be available at each port. An aggregate transmission rate of 20 kbps will be available for uplink. Thermal control will be passive, and must be provided by researchers.

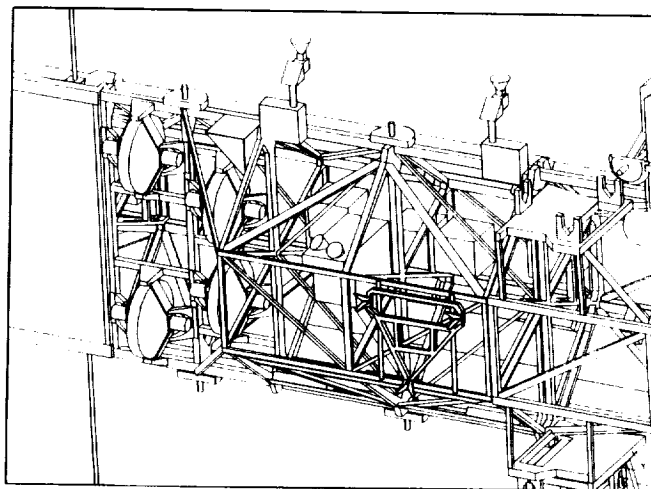


Figure 3-4 Typical Attached Payload Mechanism

ESA External Viewing Platform

ESA is planning to have an external viewing platform mounted to the aft of the APM. The preliminary platform design will accommodate a total payload mass of 4,400 lbs (2000 kg), and provide a total of 3 kW power. The platform provides access to an 802.4 data line, which has a throughput capability of up to 10 Mbps, a high rate data link, video capability, time and 100 W of safing power.

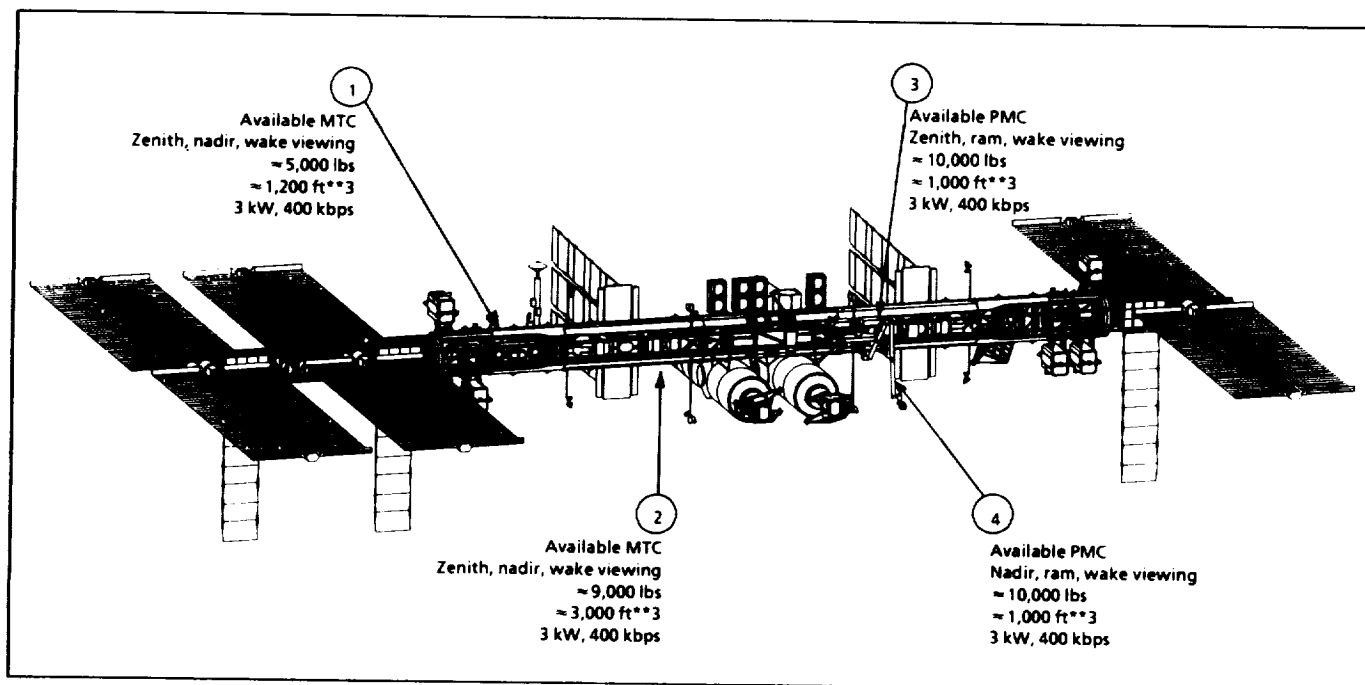


Figure 3-3 Attached Payload Truss Locations

JEM Exposed Facility

The JEM Exposed Facility (EF) shown in Figure 3-5 is a 16.4 ft (5.0 m) long structure, continuously exposed to the space environment, located at the rear of the JEM pressurized module. A remote manipulator system transports payloads between the JEM pressurized module and the EF via an airlock. The airlock is cylindrical, about 5.25 ft (1.6 m) in diameter and 7.2 ft (2.2 m) in length. The largest size equipment which can be transferred through the airlock is 19.5 x 34 x 65.4 in. (495 x 864 x 1661 mm).

The EF can accommodate 10 small to moderately sized payloads. Four of these sites are allocated to NASA. Each EF location can support attached payloads of up to 1100 lbs. (500 kg) with a payload volume of 53 ft.³ (1.5 m³) or less.

The Experiment Logistics Module-Exposed Section (ELM-ES) provides the external payload storage accommodations for payloads to be relocated to the EF. It is normally attached to the aft of the EF and can accommodate a maximum of two standard EF payloads. Power is available for payload survival heaters.

The EF power distribution system delivers a total of 3 kW to each attached payload location with a maximum of 10kW for the entire EF payload complement. The EF TCS can accommodate a total heat load of 11 kW for all attached payload locations with a maximum of 6 kW at any one location. High-rate data transfer capability exists at eight attached payload locations. Each site also has access to an 802.4 data line, which provides a throughout capability of up to 10 Mbps, and a dedicated video line.

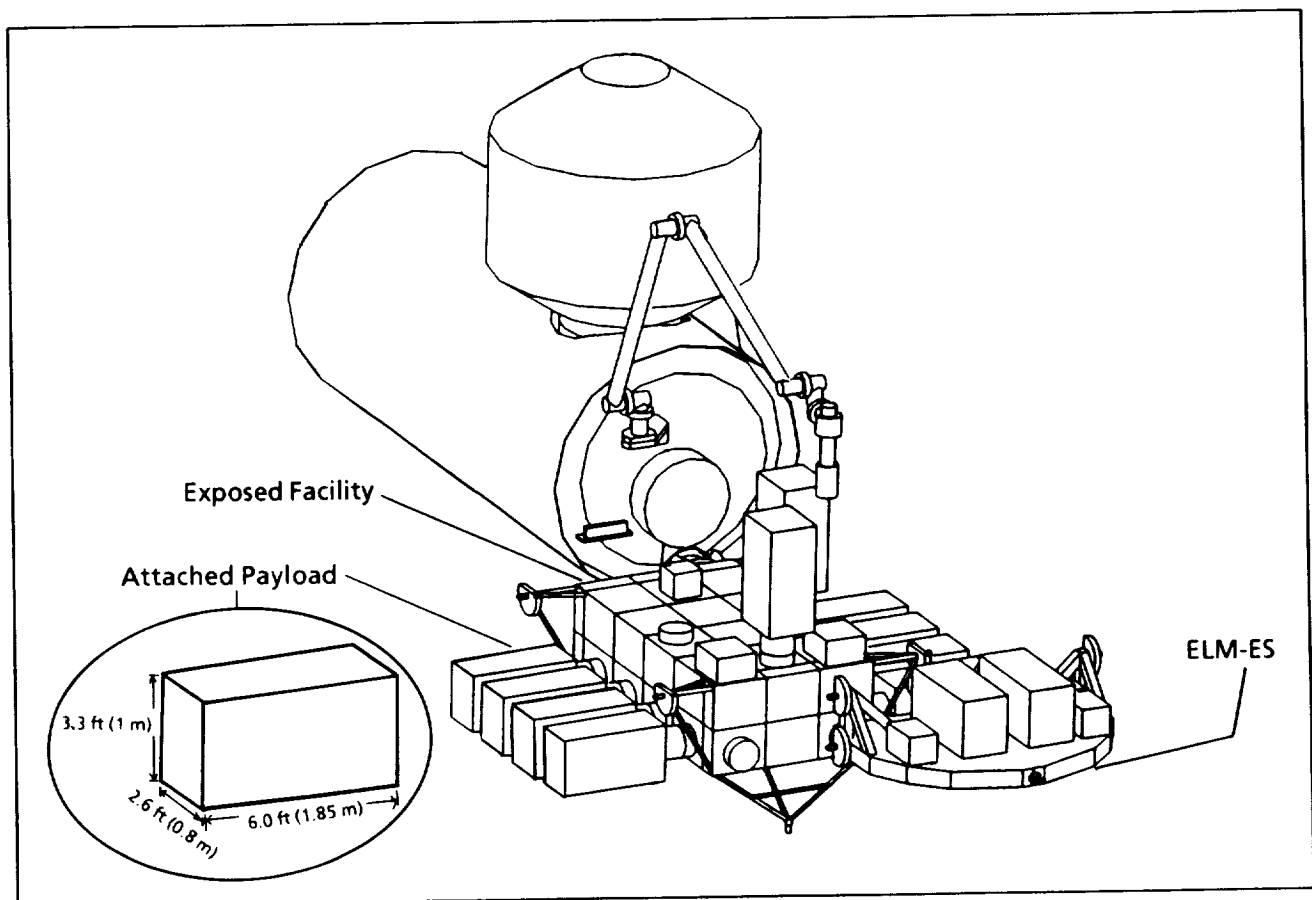


Figure 3-5 JEM Exposed Facility

4. PAYLOAD INTEGRATION PROCESS

Payload integration is the process of assembling a complement of research payloads for flight on Space Station Freedom. The process begins with flight planning and includes physical and on-orbit payload integration and deintegration, safety, verification and training, as depicted in Figure 4-1.

Flight Planning

In order to fly a payload on Space Station Freedom, information describing the payload must be provided to the SSFP. The initial payload information is submitted in the form of the Partner Utilization Plan (PUP) payload data package. The PUP payload data package must be submitted by the researcher to the NASA sponsor for each payload being considered. The PUP payload data package, as summarized in Appendix C, provides specific information concerning the payload's requirements for resources, accommodations, supporting services, operations, resources and scheduling.

Freedom's resources are allocated among the international partners based upon international agreements and among the NASA sponsors according to policies established by the NASA SSUB. The NASA PUP is the plan for utilization of resources and accommodations available to NASA. The NASA PUP is prepared annually based upon the PUP payload data packages submitted by NASA sponsors. The NASA PUP and each of the international partner PUP's are used to develop the multilateral Consolidated Operations and Utilization Plan (COUP), which provides a strategic-level summary of Freedom's operations and utilization plans.

After assessing the compatibility of a payload with Freedom's capabilities and available resources, the payload will be included in the COUP, assigning the payload to a specific year for flight.

The payload will subsequently be assigned for flight on the Station during a specific increment – the period of time between Space Shuttle arrivals at

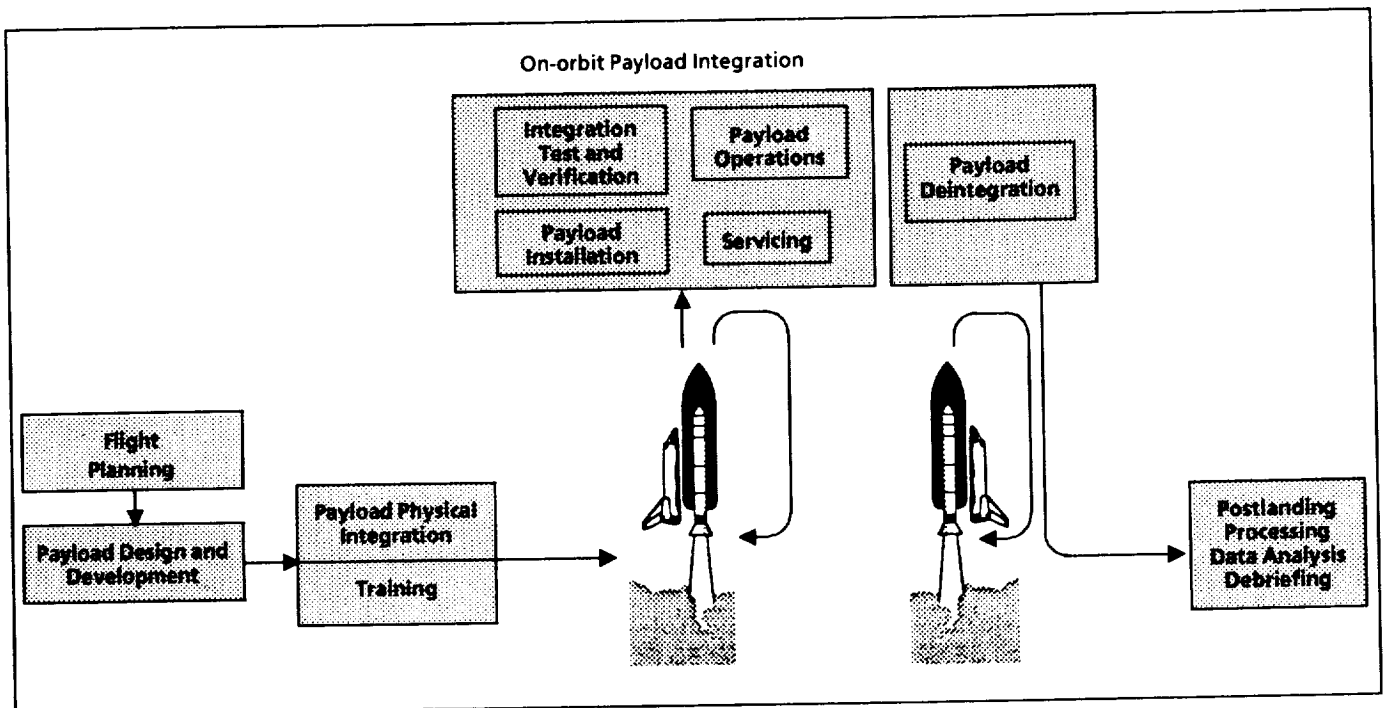


Figure 4-1 Payload Integration Process

Space Station Freedom – as flight planning progresses.

After assignment, payload integration can begin. The time required for payload integration depends upon the complexity of the payload. Researchers whose payloads are compatible with the Space Station's standard accommodations and require minimal operational resources should allow approximately one to two years for payload integration. Researchers whose payloads require nonstandard accommodations or considerable operational resources should allow more time for payload integration. The time needed is negotiated on a case-by-case basis. NASA is striving to reduce the time required for payload integration of simple payloads to six-months and additional information will be included in future updates of this guide.

A Payload Accommodation Manager (PAM) is assigned to the researcher by the SSFP following payload flight approval. The PAM is the single point of contact between the researcher and SSFP management. The PAM provides the researcher with the information and program documents needed for payload design, integration and operation. The PAM assists the researcher in developing integration schedules and milestones. The researcher is responsible for submitting integration safety and verification data to the SSFP as negotiated and defined in payload integration agreements.

Training

Researchers are responsible for training the Station crew and ground personnel in the operation and maintenance of their payloads. Researchers also undergo training provided by the program, in concert with the crew. This training familiarizes the researchers with the command procedures for normal and contingency situations, and teaches them about the command and control system used to ensure that payload operations do not conflict with one another or overall station operations.

Payload Physical Integration

Prior to launch, payloads destined for Freedom's pressurized modules must be integrated with racks. The racks are then installed into a pressurized logis-

tics module (MPLM or PLM) at KSC, for transport to Freedom via the Space Shuttle. Payloads to be attached to the truss or the JEM EF are attached to unpressurized logistics carriers at KSC, also for transport via the Space Shuttle.

Researchers are responsible for the testing and verification of their payloads. It must be demonstrated that the operation of a payload will not compromise safety or interfere with other payloads. All payload racks must pass a Final Interface Verification Test (IVT) at KSC to demonstrate the compatibility between the integrated payload rack and simulated Station interfaces.

On-orbit Payload Integration

After the Shuttle docks with Freedom and the pressurized logistics module is attached, the Space Station crew installs the new payload racks on board. Attached payloads are attached to the truss or to the JEM EF. Once the researcher's payload is in place, it must undergo an on-orbit checkout to ensure that it is functioning properly.

From an operations facility, the researcher issues the commands required to complete checkout and verification and oversees the activities of the crew. The Payload Operations and Integration Center (POIC) integrates the researcher's commands with those of all other users for transmission to Freedom. The crew integrates the payload and performs checkouts or on-board adjustments according to plan. Once the payload and systems checkouts have been completed, payload operations can begin.

Payload Deintegration

When a payload is to be returned to Earth, the crew deintegrates the payload following procedures prepared by the researcher.

Once the payload has returned, the SSFP ensures that the researcher receives the payload and any product and/or data in accordance with the preflight agreements.

A debriefing with the researcher, the sponsor and the SSFP is held after the researcher completes analysis of the payload data, samples or specimens. The de-

briefing allows the parties to review the flight and the results obtained from the research.

NASA-funded researchers are expected to provide a formal report containing experiment results, analysis and conclusions to their sponsors and to submit final data to the appropriate data archives. The program and commercial reimbursable researchers meet to review agreements to ensure all obligations have been fulfilled. Researchers with proprietary rights report in accordance with preflight agreements.

Safety

Safety is a primary concern of the Space Station Freedom program. The SSFP is responsible for assuring that hazards are not created between payloads, or between any payload and any part of the Space Station structure, transport vehicles and supporting systems. A payload owner/developer is expected to design and plan for operational use of the payload with the safety of the Station and crew as a major concern.

The SSFP safety certification program maximizes safety while employing procedures that minimally inhibit or impede payload design, integration and operations processes.

Researchers are responsible for certifying the safety of payload equipment and payload operations. The

researcher-supplied data is reviewed by payload safety panels. Payload safety compliance is assessed against the requirements specified in:

- Space Station Freedom Payload Safety Review Process SSP 30595, current issue
- Space Station Freedom Payload Safety Requirements for On-Orbit Operations, SSP 30652 (NSTS 1700.7B Addendum 1)

The assurance of safety for Space Station payloads is accomplished through a series of safety reviews. Individual payload safety certification reviews are closely associated with the payload's design and development milestones. During the reviews, the researcher presents a brief description of the payload, its support equipment and its operation, followed by data unique to the particular review. The depth of reviews depends upon the complexity, technical maturity and hazard potential of the payload.

Following certification of individual payloads, increment safety reviews are conducted on the integrated payload complement. These reviews are held to assess the safety of the increment payload complement and to consider the overall synergistic effect of the payload complement and its operations.

5. GROUND AND SPACE OPERATIONS

Ground and space operations encompass preflight payload processing at the Kennedy Space Center (Figure 5-1), training, on-orbit payload operation and control, and postlanding operations.

KSC Preflight Operations

Once a payload arrives at KSC, it will follow one of the payload integration and processing flows depicted in Figure 5-2. A generic payload processing scenario is described below.

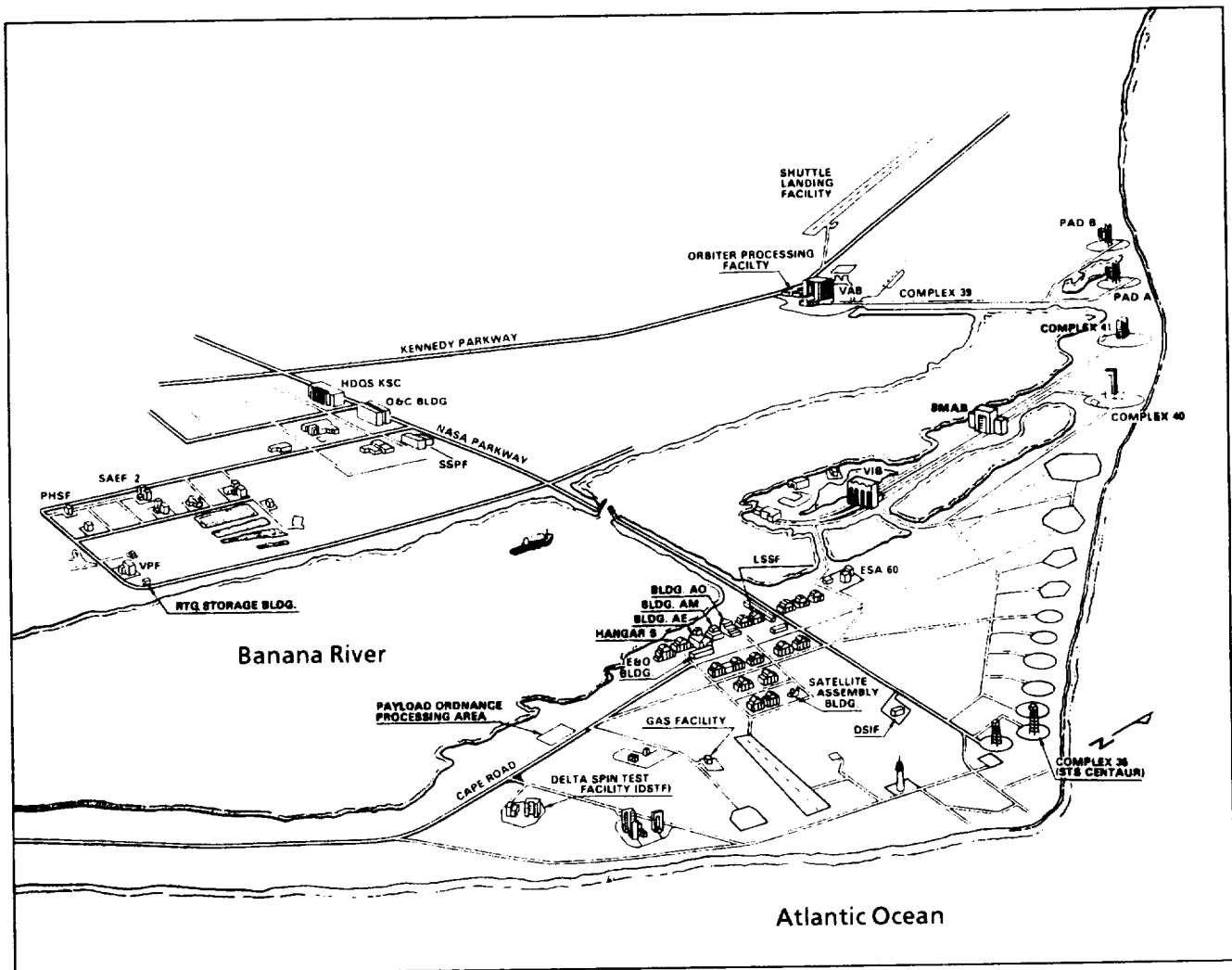


Figure 5-1 Layout of Kennedy Space Center

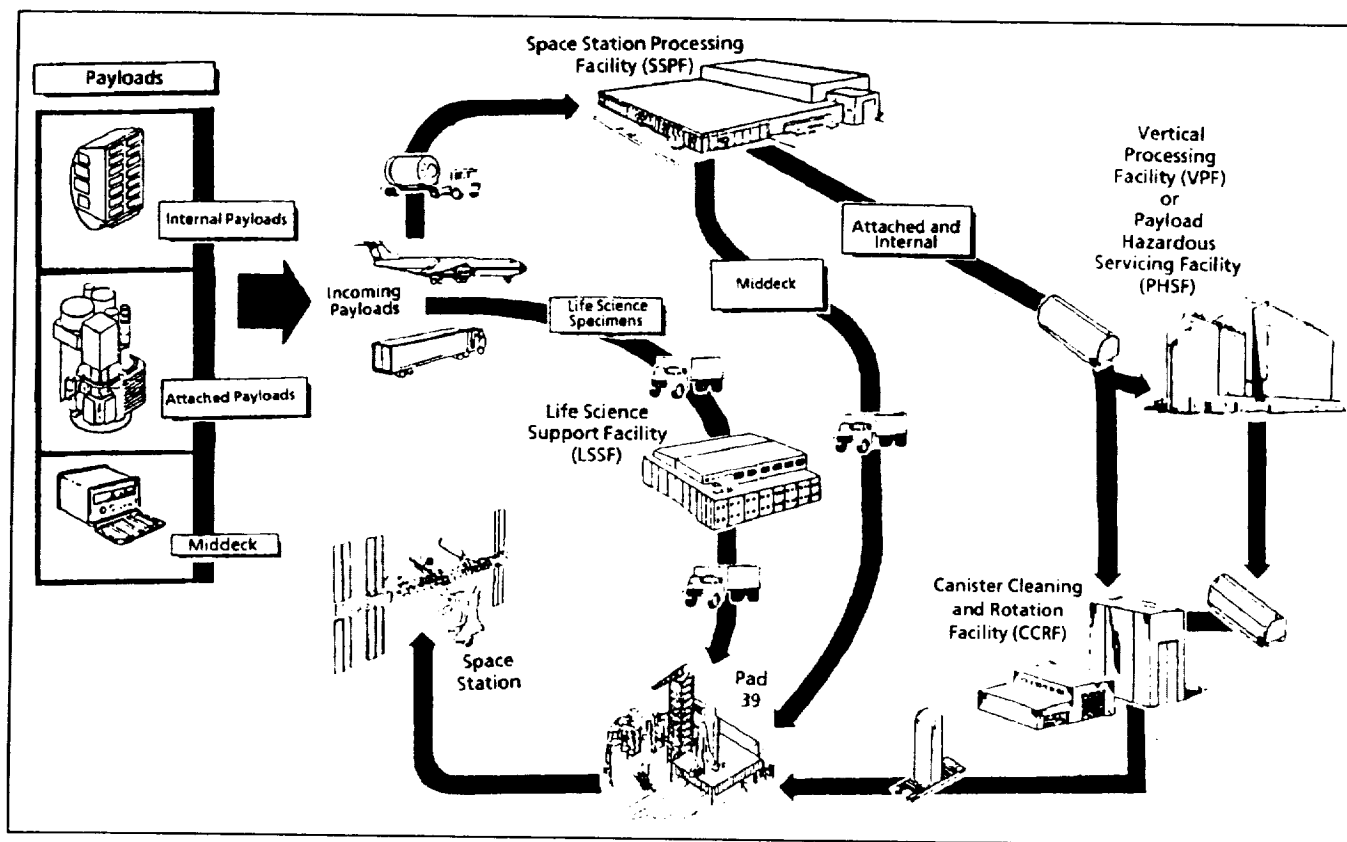


Figure 5-2 Space Station Payload Processing Flow

When a payload arrives at KSC it is assumed that:

- All manufacturing and assembly has been completed
- Program acceptance testing and flight certification has been completed
- All documentation has been completed
- All equipment will arrive in the same shipment

Equipment shipped incomplete, short of parts, unassembled or with incomplete documentation will be accepted at KSC only if arrangements for additional support and services have been negotiated with KSC prior to shipment.

The payload is unloaded from the off-site carrier (plane, ship, rail car, or truck) at the appropriate unloading area. The payload is unpacked from its shipping container and visually inspected by KSC personnel to verify and document the quantity and

condition of the payload components. Typically, a researcher is assigned to an off-line laboratory for detailed inspection and checkout of the payload. In the laboratory the researcher may assemble, calibrate and verify the operation of the payload and its ground support equipment (GSE) prior to subsequent processing and testing. This completes the pre-integration of the payload.

Payload-to-rack integration can occur at an off-site facility. Payload-to-rack integration at KSC is done at the Space Station Processing Facility (SSPF). The integrated payloads may undergo some agreed-to functional testing in the SSPF. The functional test verifies communication between payloads and rack subsystems, which completes payload integration.

All payload racks must then pass a Final Interface Verification Test (IVT) at KSC. This test demonstrates the compatibility between the integrated payload rack and the simulated Station interfaces. The simulators are provided by the SSPF.

The remaining processing includes Space Station integration, launch package integration, and orbiter integration. Space Station integration includes payload carrier-to-element interface verification (for example, rack with experiment to logistics module). Launch package integration includes configuration for launch and testing of Space Station to simulated Space Shuttle interfaces as required, integration with the Shuttle's canister, stowage of nonhazardous material, and hazardous operations as required. Orbiter integration includes the transportation of the launch package to the launch pad, insertion of the package into the orbiter, interface verification as required, pad operations, servicing, closeout, launch operations, and the flight to the Space Station.

The Space Station Freedom program has developed security measures to provide protection to payloads during ground operations at KSC. Researchers will be briefed on the specifics of these measures during their payload development cycle. If necessary, additional security measures may be available from the SSFP on a negotiated basis.

Researchers are responsible for performing several activities during preflight operations. These responsibilities include:

- Preparation of procedures for and performance of off-line processing.
- Provision of operational and logistics support of their hardware during off-line operations.
- Establishment of specific assembly, integration, test, verification, servicing, proprietary operations, payload configuration verification and support requirements.
- Identification of risks and potential problems associated with ground processing.
- Identification of a single point of contact for coordination with launch and landing sites.
- Provision of input to and review of ground integration and test procedures involving researcher hardware, software and support equipment.
- Identification of hazardous operations and provision of hazard and safety requirements.

- Provision of technical support for real time problem resolution during testing.
- Design of proprietary protection into the payload.
- Planning and performance of payload unique servicing, with KSC support.

On-orbit Payload Operations

The researcher receives data from the payload while it is operating on orbit to determine whether it is functioning as planned, or whether changes are necessary. While the payload is in orbit, the researcher performs operations and oversees any actions taken by the crew with regard to the payload. The researcher is also responsible for monitoring the status of the payload to ensure that it remains in a safe operating mode.

For researchers who require near real time data from their payload, the DMS, and the C&T system, downlink the payload data via the TDRSS to the receiver at White Sands, New Mexico. The data is then forwarded to the researcher's facility, as negotiated. In addition, the DMS extracts previously specified data necessary for researcher processing of the payload data from the core operations data stream. The DMS forwards these data to the C&T system for near real time downlink to the researcher's facility.

Some payloads may be on the Station for more than one increment. The researchers may receive data in near real time, at prescheduled times, or upon the return of their payload. The mode of data transmission is dependent upon the nature of the payload and the researcher's data requirements.

Facilities and Services

Several NASA facilities provide essential services to Space Station Freedom:

- Space Station Processing Facility
- Life Sciences Support Facility

- Space Station Control Center
- Payload Operations Integration Center

Space Station Processing Facility (SSPF)

The SSPF at KSC is the primary location where pre-launch payload processing and support occurs. It is a 264,000 square foot building designed specifically for the processing of Space Station Freedom system hardware and payloads. A high bay is available for on-line module processing and canister operations. An intermediate bay provides rack and attached payload processing areas. Logistics and support areas are also available. Figure 5-3 shows the typical payload processing flow in the SSPF.

Nineteen laboratories that meet 100K Clean Work area specifications are located in an area adjacent to the intermediate bay. These labs may be used by technical support teams from organizations with special experiments underway in the SSPF. There are two chemical labs and two dark rooms. In addition, five 400-ft², six 500-ft², two 600-ft², one 800-ft², and one 1,000-ft² labs are available for general experiments. All labs are equipped with power and communications. Three labs are equipped with fluids and facility exhaust ventilation systems.

Payload processing ground support equipment (GSE) and simulators are provided in the SSPF. Typical services which can be provided to payloads on a negotiated basis include:

- Simulators, including: U.S. Lab, ESA APM, JEM, and JEM Exposed Facility
- Test, Control and Monitor System (TCMS)
- Mechanical attachment devices (e.g. racks and dollies)
- Power
- Data and command services
- Thermal control

In the event that the required GSE exceeds SSPF capabilities, the researcher must provide the necessary hardware and software to verify payload operations.

Unique payload holding and handling fixtures are also the responsibility of the researcher.

Life Sciences Support Facility (LSSF)

The LSSF at KSC provides researchers with the facilities for receiving and housing animals and their food supplies; cleaning, sanitizing, and storing cages/equipment; collecting and disposing of waste; laboratory support; hygiene facilities for personnel; flight animal isolation; and plant research.

Specimen holding is available for small mammals, fish, amphibians, and plants. Laboratories are equipped for handle these specimens as well as cells, tissues and microorganisms. The LSSF also contains areas for surgery, X-ray, data management, storage, synchronous ground control and flight experiment monitoring, and provides additional expansion capabilities for overlapping mission support.

All animals undergo a health inspection before being brought into the LSSF. Paperwork on the animals must precede their arrival. Animals are processed into the LSSF through a portable clean room. They are placed in one of seven animal holding rooms (AHRs) for a stabilization and monitoring period. The animals are next placed in the appropriate AHR for flight preparation and eventual specimen selection. Animals selected as ground controls are placed in a designated AHR.

Plants, cultures, seeds and support supplies are placed in biological laboratories specifically configured for the experiment that will make use of them.

In addition to the technical facilities, office space is available for visiting researchers. Since the facility may be utilized by several payload elements at any given time, researchers should coordinate their requirements in advance with the PAM.

Space Station Control Center (SSCC)

The SSCC, located at JSC, is the ground facility that controls Space Station operations. It is used for resource utilization planning, management and control of air-to-ground data and voice links, and support for systems and user operations replanning. It provides around-the-clock control of Station operations.

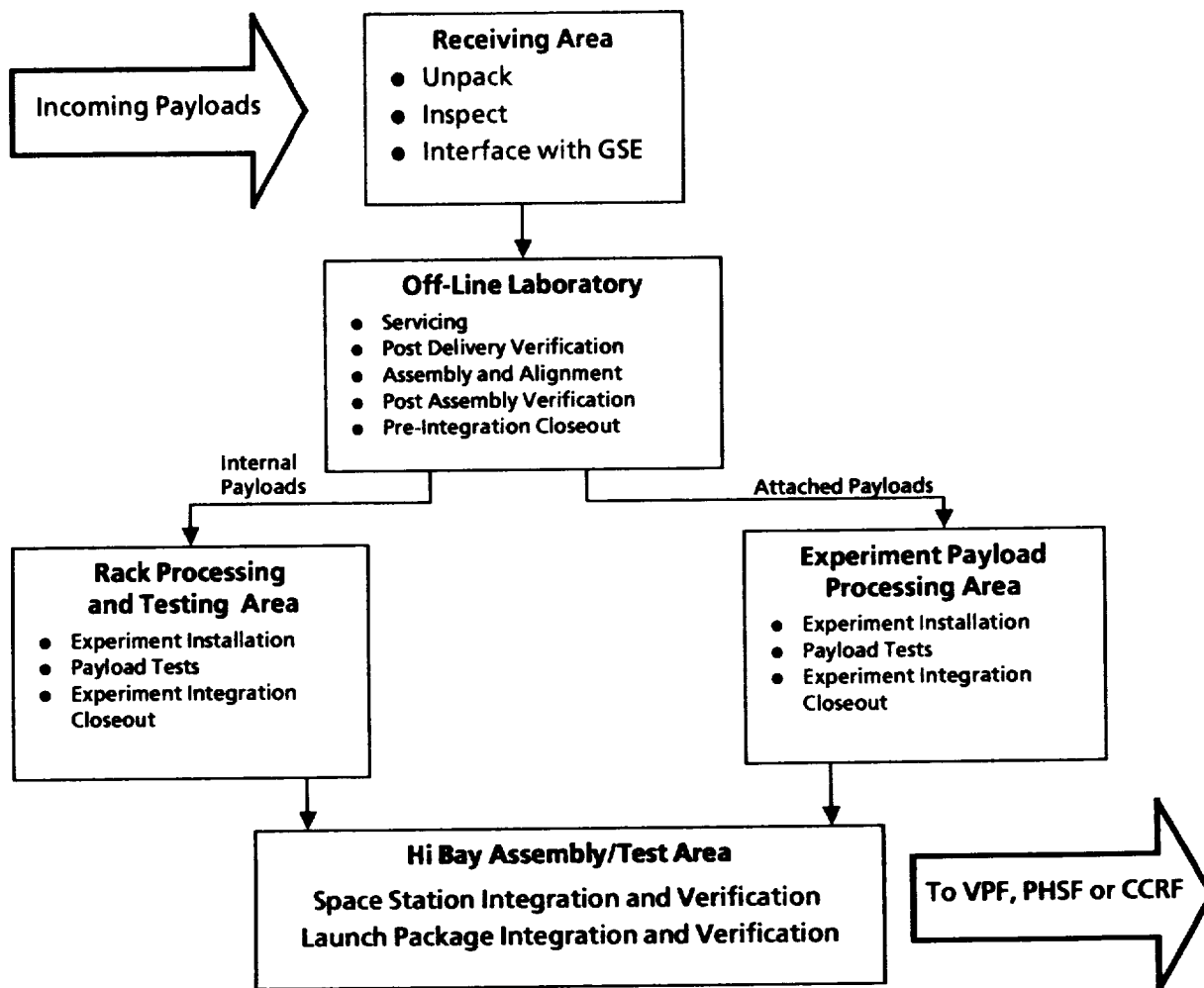


Figure 5-3 Generic Overview of Payload Processing Flow in SSPF

Payload Operations Integration Center (POIC)

The POIC is located in the same building as the Huntsville Operations Support Center (HOSC) at the Marshall Space Flight Center. The POIC coordinates researcher activities for the Space Station, and schedules user operations consistent with SSCC resource allocations, guidelines and constraints. The POIC integrates researcher requirements according to researcher resource envelopes and available resources; assists in replanning; aids in resolving conflicts and supports distributed researcher facilities in near real time execution activities. On-orbit crew time and other resources available for researchers are managed by the POIC in cooperation with the SSCC.

The POIC knows of all payload operations and servicing requirements to be performed on Freedom as well as the launch and landing site. The POIC assists researchers in the evolution of these requirements into end-to-end payload increment operations plans, procedures and schedules. The POIC works with researchers to schedule activities within the payload operations windows. The resulting plan is sent to the SSCC for inclusion in the increment operations plan (IOP).

The POIC interfaces as required with the launch site to assist in developing and integrating related payload requirements into logistics support plans and prelaunch and postlanding processing plans.

The POIC also provides real time support to payload operation and servicing requirements. POIC personnel manage the daily flow of researcher-to-manned base communications. The POIC arbitrates conflicts concerning the scheduling of payload operations, operations priorities, and payload resource allocations and represents the researcher to the SSCC for resource allocation tradeoffs between Station systems and payloads.

In the event of unforeseen schedule conflicts, resource constraints, or technical anomalies, replanning of some payload operations may be required. Both the POIC and the SSCC are capable of providing real time replanning support to researchers and to the onboard crew in order to minimize disruptions to payload operation schedules. At the beginning of each increment, an iterative payload operations replanning effort is likely to be the rule rather than the exception. Additionally, should unforeseen opportunities arise to collect valuable scientific data, the POIC will coordinate such special requests from researchers with the SSCC.

Trajectory and altitude data, voice and command link allocations, resource allocation updates, and Station crew and systems status information are continuously available to researchers to support replanning and operations.

The POIC and Freedom data communications network enable researchers to control payload operations from geographically dispersed locations. A

group of researchers with common interests could implement an operations facility, for example.

Using telescience, the data communications network enables researchers to operate payloads in near real time from remote facilities. Telescience permits researchers to work freely within their resource envelope (power, bandwidth, etc.). However, payload operations that exceed the envelope, affect the safety of the Space Station or crew, or affect the payloads of other researchers, are not permitted.

The POIC provides interfaces that allow geographically dispersed researchers to access the POIC. Via the POIC researchers may:

- Send real time commands, payload software, operations parameters, and stored commands
- Modify payload software
- Manage and transmit data
- Verify payload interfaces
- Obtain and monitor payload status and performance.

Training

The Space Station Freedom training program is a multinational, multi-center, multi-year effort. Training is conducted at participating NASA Centers, international partner facilities and researcher facilities. Training is provided to the crew, Ground Support Personnel (GSP) and Space Station researchers. The SSFP provides researchers with training guidelines.

MSFC manages payload training and ensures that the flight and ground personnel are trained to implement planned flight payload operations in a safe and effective manner. MSFC plans and coordinates Space Station training activities and supports researchers in the maintenance of payload trainer hardware and software.

Payload Operations Training

Payload operations training for the flight crew is conducted both by the payload developers and the Payload Training Complex (PTC) at MSFC. The development of hardware and software models and other necessary training materials for a given payload is the responsibility of the researcher or sponsor. Prior to training, payload training simulations are integrated into the PTC, which includes a full scale U.S. Laboratory Module simulator and single system simulators for NASA payloads that will fly in the JEM or the ESA APM.

Flight Crew Training

A flight crew is assigned to a specific increment no later than 18 months prior to flight. Each researcher with a payload on that increment trains the crew on the systems and operation of the payload and offers background information about the scientific discipline associated with the payload. The training can include lectures and hands-on sessions with the flight hardware and a payload simulator. The researcher develops the training media (hardware, software and

courseware) and must provide training material that accurately reflects their payload's configuration and operation. Training takes place at the payload developer's site, which may be anywhere in the world, or researchers may bring their training media and personnel to MSFC to deliver training.

The flight crew also trains at the PTC, where the training emphasizes the interaction of payloads of the same scientific discipline, stresses team training of the Station's entire payload complement and develops coordination between the flight crew and payload controllers via integrated simulations with the POIC.

Flight crew team training at the SSTF emphasizes Space Station systems and the interaction between payloads and systems. The focus is on full task entire Space Station and ground support operations, with an emphasis on critical operations and safety drills.

Researcher Training

The formal training of the researcher commences approximately one year prior to the flight increment. The researcher is taught the basics of interacting with the SSMB via the POIC during real time operations, including resource allocation protocols, on-orbit execution activities, and dispute/conflict resolution procedures. In addition, NASA provides the researcher with training on data and communications protocols; i.e., how to uplink commands and receive experimental data.

Ground Support Personnel Training

Ground support personnel (GSP) are trained in the operation of systems and payloads. GSP provide support for payload activities during MTC when the Station is unattended. Each NASA Center and international partner is responsible for systems training of their own GSP, and researchers are responsible for the training of GSP in the operation of their payloads. Training covers day-to-day operations, malfunctions, safing, shutdown, etc.

Postlanding Operations

The primary landing site for the Shuttle's return from the Space Station is KSC. Following the return, samples and specimens are sent to an off-line laboratory in the SSPF or other facility for analysis and processing, as negotiated. Should unfavorable weather conditions exist at KSC, the Space Shuttle will land at Edwards Air Force Base in California. Since there is no permanent payload processing support equipment at Edwards AFB, processing is limited to the early access of critical samples and specimens located

in the orbiter middeck after orbiter safing, cooling, electrical power connection, and crew egress functions are complete.

Payloads that do not require early access upon return are all handled at KSC, regardless of the landing site. Payloads are removed from the Space Shuttle's payload bay, placed in a canister, and transported to the SSPF or PHSF, where they are removed from the canister. They are then sent to their original integration site for deintegration, where they are removed from the racks or carrier.

APPENDIX A: ABBREVIATIONS AND ACRONYMS

| | | | |
|-----------------|--|----------------|---|
| ACRV | Assured Crew Return Vehicle | IVA | Intravehicular Activity |
| AFB | Air Force Base | IVT | Interface Verification Test |
| AHR | Animal Holding Room | JEM | Japanese Experiment Module |
| AMS | Acceleration Mapping System | JSC | (Lyndon B.) Johnson Space Center |
| AO | Announcement of Opportunity | kbps | kilobits per second |
| APM | Attached Pressurized Module | kg | kilogram |
| C | Celsius | km | kilometer |
| CCRF | Canister Cleaning & Rotation Facility | kmph | kilometers per hour |
| C&T | Communications and Tracking | kPa | kilopascal |
| CCDS | Center for Commercial Development of Space | KSC | (John F.) Kennedy Space Center |
| CHeCS | Crew Health Care System | kW | kilowatt |
| cm | centimeter | L | launch |
| CO ₂ | carbon dioxide | Lab | laboratory |
| COUP | Consolidated Operations and Utilization Plan | LAN | local area network |
| dc | direct current | lbs | pounds |
| deg | degrees | LEO | low Earth orbit |
| DMS | Data Management System | LeRC | Lewis Research Center |
| ECF | Exercise Countermeasure Facility | LSE | Laboratory Support Equipment |
| ECLSS | Environmental Control and Life Support System | LSSF | Life Science Support Facility |
| EF | Exposed Facility | m | meter |
| EHS | Environmental Health System | MB | Mission Build |
| ELM | Experiment Logistics Module | Mbps | megabits per second |
| ELM-ES | Experiment Logistics Module-Exposed Section | MIL-STD | Military Standard (specification) |
| ELM-PS | Experiment Logistics Module-Pressurized Section | mm | millimeter |
| EM | electromagnetic | mos | months |
| EMR | electromagnetic radiation | MPAC | Multipurpose Application Console |
| EPS | Electrical Power System | mph | miles per hour |
| ESA | European Space Agency | MPLM | Mini-Pressurized Logistics Module |
| F | Fahrenheit | MSC | Mobile Servicing Center |
| FDDI | Fiber Distributed Data Interface (optical fiber) | MSFC | (George C.) Marshall Space Flight Center |
| FEL | First Element Launch | MSS | Mobile Servicing System |
| ft | foot | MT | Mobile Transporter |
| g | Earth's gravity | MTC | Man-Tended Capability |
| GLSF | General Laboratory Support Facilities | N ₂ | Nitrogen |
| GN&C | Guidance, Navigation and Control | N/A | not applicable |
| GSE | Ground Support Equipment | NASA | National Aeronautics and Space Administration |
| GSP | Ground Support Personnel | NASDA | National Space Development Agency (Japan) |
| Hab | Habitation Module | n.m. | nautical mile |
| HMF | Health Maintenance Facility | NRA | NASA Research Announcement |
| HRL | High Rate Link (data) | NTSC | National Television System Committee |
| hrs | hours | OAST | Office of Aeronautics and Space Technology |
| Hz | Hertz | OCP | Office of Commercial Programs |
| ICD | Interface Control Document | OS | operating system |
| IDD | Interface Definition Document | OSF | Office of Space Flight |
| IEEE | Institute of Electrical and Electronic Engineers | OSSA | Office of Space Science and Applications |
| in. | inch | OSSD | Office of Space Systems Development |
| IOP | Increment Operations Plan | PAM | Payload Accommodations Manager |
| IROP | Integration Requirements on Payloads | PDRD | Program Definition and Requirements Document |
| ISPR | International Standard Payload Rack | PHSF | Payload Hazardous Servicing Facility |
| ITA | Integrated Truss Assembly | | |

| | | | |
|-------------|--|--------------|---|
| PIA | Payload Integration Agreement | SSFP | Space Station Freedom Program |
| PLM | Pressurized Logistics Module | SSPF | Space Station Processing Facility |
| PMC | Permanently Manned Capability | SSTF | Space Station Training Facility |
| POIC | Payload Operations Integration Center | SSUB | Space Station Utilization Board |
| psia | pounds per square inch absolute | TBD | to be determined |
| PTC | Payload Training Complex | TCMS | Test Control and Monitoring System |
| PUP | Partner Utilization Plan | TCS | Thermal Control System |
| PV | photovoltaic | TDRS | Tracking and Data Relay Satellite |
| RC | Ring Concentrator | TDRSS | Tracking and Data Relay Satellite System |
| RFF | Request for Flight | TDS | Time Distribution System |
| RMS | Remote Manipulator System | UF | Utilization Flight |
| RTE | run time environment | UHF | ultra high frequency |
| SDP | Standard Data Processor | ULC | Unpressurized Logistics Carrier |
| SEU | Single Event Upset | U.S. | United States |
| SPDM | Special Purpose Dexterous Manipulator | V | volts |
| SSCC | Space Station Control Center | VAB | Vehicle Assembly Building |
| SSF | Space Station Freedom | VPF | Vertical Processing Facility |
| | | ZOE | Zone of Exclusion |

APPENDIX B: LIST OF PROGRAM AND RELATED DOCUMENTS

The following documents relate to Space Station Freedom users. Availability depends upon the status of document development.

NASA-Provided Documents

Space Station Freedom User's Guide

Space Station Freedom Payload Accommodation Handbook

Program Definition and Requirements Document (PDRD), Section 5 Payload Accommodations

Space Station Freedom Integration Requirements on Payloads (IROP)

Space Station Freedom Standard Interface Control Documents (ICDs)

Space Station Freedom Payload Integration Agreements (PIAs) and Annexes

Space Station Freedom Interface Definition Documents (IDDs)

Space Station Freedom System Description and Design Data Handbooks

Space Station Freedom Standard Integration Plans

Space Station Freedom User's Reimbursement Guide

Space Station Freedom Payload Safety Review Process SSP 30595

Space Station Freedom Payload Safety Requirements for On-orbit Operations SSP 30652 (NSTS 1700.7B Addendum 1)

Space Station Payload Ground Operations Plan

KSC Prelaunch/Postlanding Operations Plan

Information Services User's Guide

Data Management System User's Guide

Tracking and Data Relay Satellite System User's Guide

Space Transportation System User Handbook

NSTS 07700 Volume XIV Space Shuttle System Payload Accommodations

User-Provided Documents

Partner Utilization Plan Payload Data Package

Tactical Payload Data Package

Payload Integration Data Package

Payload Verification Plan

Payload Safety Compliance Data Package

Payload Verification Data Report

Payload Safety Compliance Data Report

Integration Acceptance Data Package

Payload Training Plan

Operations Plan

Material Handling and Disposition Plan

Payload Return Plan

User's Lessons Learned Report

Data Use and Archive Plan

For information about, any of these documents, contact:

The Office of Space Flight
Spacelab/Space Station Utilization Program
User Integration Division
Code MG
NASA Headquarters
Washington, DC 20546

APPENDIX C: PARTNER UTILIZATION PLAN (PUP) PAYLOAD DATA PACKAGE

The following information represents top-level payload information used by NASA to develop annual Space Station utilization plans. Researchers provide this information to their NASA sponsors for each payload being considered for the first time. Space Station utilization resources are allocated based upon this information.

- | | | | |
|-----|--|-----|---|
| 1 | Primary Point of Contact | 14e | External Deployed Height [m] |
| 2 | Institution | 14f | External Packaged Length [m] |
| 3 | Address | 14g | External Packaged Width [m] |
| 4 | Electronic Address | 14h | External Packaged Height [m] |
| 5 | Telephone Number | 14i | Viewing Direction Required |
| 6 | Full Payload Name | 15 | Required Space Shuttle Transported Mass: |
| 7 | Short Payload Name | 15a | Resupply Up Mass [kg] |
| 8 | Objective | 15b | Payload Up Mass [kg] |
| 9 | Method | 15c | Resupply Down Mass [kg] |
| 10 | Other Coordinated Payloads Required On Board Simultaneously | 15d | Payload Down Mass [kg] |
| 11 | Average Operating Power [watts] | 15e | Resupply Up Volume [double racks] |
| 12 | Total Crew Time Required [hours/year] | 15f | Resupply Down Volume [double racks] |
| 13 | User Servicing Capacity [yes/no] | 16 | Average TDRSS Data Rates: |
| 14 | Pressurized/Unpressurized Accommodations [P/U]: | 16a | Uplink [kbps] |
| 14a | SSF Racks [double racks] | 16b | Downlink [kbps] |
| 14b | Laboratory Support Equipment Required | 17 | Total Operating Time [hours/year] |
| 14c | External Deployed Length [m] | 18 | Planned Time On Board [months] |
| 14d | External Deployed Width [m] | 19 | Late/Early Access [launch/return/both/none] |
| | | 20 | Launch/Return Refrigerator/Freezer [launch/return/both/none] |
| | | 21 | Onboard Data Storage [MB] |
| | | 22 | Additional Requirements |
| | | 23 | Comments |

APPENDIX D: RESEARCHER RESPONSIBILITIES

This Appendix summarizes the researcher's responsibilities. It is not all-inclusive, but does provide the researcher with an overview of what to expect and what is required. Specific responsibilities will be defined as a researcher progresses through the program.

Researcher Responsibilities

- Get a Sponsor
- Provide Partner Utilization Plan (PUP), Payload Data Package
- Provide a Standard Data Processor for direct connection with the FDDI payload network, if payload requires a direct connection.
- Provide thermal control for truss attached payloads
- Provide any data encryption
- Guarantee payload safety and provide protection for payload and associated ground systems
- Provide the necessary interface electronics if high rate data links are used
- If video data is required, purchase camera from the SSFP or provide one which has a pulse frequency modulated optical signal that is compatible with the National Television System Committee standard.
- Provide containment, storage and transport hardware for gases which cannot be rented
- Provide contaminant storage and transport hardware for all payload-generated liquid and solid waste
- Provide three levels of containment for hazardous materials
- If water is needed by the payload, provide containers for transfer from the water source to the payload
- Provide payload integration, safety and verification data
- Provide input to the increment operations plans
- Develop and document payload specified logistics requirements for the payload's life cycle
- Train station crew and ground personnel in the operation and maintenance of the payload
- Provide the necessary hardware, software and other materials needed for training
- Receive SSFP-provided training for command and control procedures and data and communications protocols
- Integrate payload with SSFP-furnished rack at a researcher-provided payload integration center or at the launch site as negotiated with the SSFP
- Prior to shipment to the launch site:
 - Complete all manufacturing and assembly
 - Complete acceptance testing and flight certification
 - Complete all documentation
 - Ship all equipment together
- After arrival at the launch site:
 - Conduct a detailed inspection and check-out of the payload
 - Provide payload unique ground support equipment
- Assist in on-orbit payload checkout and verification
- Monitor on-orbit payload status to assure safety
- Interface with POIC for replanning
- Monitor and assist, as needed, in the on-orbit payload deintegration
- Participate in debriefing

(Cut along line)

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Is the Guide informative? ☐ Yes ☐ No

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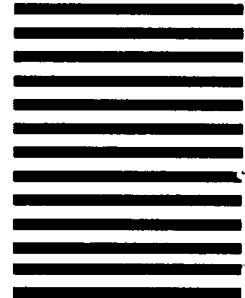


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